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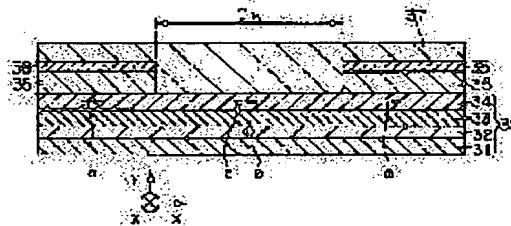
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(54) MAGNETO RESISTANCE EFFECT TYPE SENSOR, AND ITS MANUFACTURE, AND MAGNETIC HEAD EQUIPPED WITH THE SENSOR

(57)Abstract:

PROBLEM TO BE SOLVED: To provide a magneto resistance effect type of sensor which is excellent in corrosion resistance and in which an exchange anisotropic magnetic field necessary and sufficient in a film can be applied and also which is excellent in linear responsiveness and suppresses Barkhausen noise.

SOLUTION: This sensor is provided with at least two layers of ferromagnetic layers 32 and 34 through a nonmagnetic layer 33, and as regards one hand out of the ferromagnetic layers 32 and 34, the coercive force is enlarged by the coercive force increasing layer 31 of an antiferromagnetic substance provided next to the ferromagnetic layer, and the reversal of the magnetization is pin- fixed, and the reversal of magnetization of the other ferromagnetic layer is free. In this case, to the ferromagnetic layer 34 where the reversal of the above magnetization is free, an antiferromagnetic layer 35 is arranged adjacently, which applies longitudinal bias to this ferromagnetic layer 34 and induces magnetic anisotropy by a unidirectional exchange bias magnetic field so as to stabilize the magnetic block.



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CLAIMS

[Claim(s)]

[Claim 1] A two-layer ferromagnetic layer is prepared through a non-magnetic layer at least. The inside of said ferromagnetic layer, Coercive force is enlarged by the coercive force increase layer which consists of the 1st antiferromagnetic substance with which one side adjoined the ferromagnetic layer, and was prepared, and pinning of the flux reversal is carried out. It is the magneto-resistive effect mold sensor by which it comes to free flux reversal of the ferromagnetic layer of another side. As opposed to the ferromagnetic layer which comes to free said flux reversal The magneto-resistive effect mold sensor characterized by coming to carry out contiguity arrangement of the antiferromagnetism layer which consists of the 2nd antiferromagnetic substance which impresses vertical bias to this ferromagnetic layer, is made to carry out induction of the magnetic anisotropy by the exchange bias field of tropism on the other hand, and stabilizes a magnetic domain.

[Claim 2] The magneto-resistive effect mold sensor according to claim 1 characterized by coming mutually to carry out the abbreviation rectangular cross of magnetization of the ferromagnetic layer to which pinning of said flux reversal was carried out, and the magnetization of the ferromagnetic layer by which magnetization was freed in the condition that there is no external magnetic field.

[Claim 3] The magneto-resistive effect mold sensor according to claim 1 or 2 by which coercive force of the ferromagnetic layer by which pinning was carried out to this coercive force increase layer in flux reversal by said coercive force increase layer consisting of alpha-Fe 2O3 is characterized by the thing which is done to a ferromagnetic layer by said coercive force increase layer for induction, and which it comes it to carry out larger than the exchange bias field of tropism on the other hand.

[Claim 4] The magneto-resistive effect mold sensor according to claim 1 to 3 characterized by the 2nd antiferromagnetism layer for said vertical bias impression opening the predetermined width of recording track equivalent to the width of face of a magnetic sensitive part in the both-ends side of the magnetic sensitive part of the ferromagnetic layer which it comes to free in said flux reversal, and coming to carry out opposite arrangement in contact with a ferromagnetic layer.

[Claim 5] The freed ferromagnetic layer said flux reversal by the layered product with other ferromagnetic layers by which the laminating was carried out to the antiferromagnetism layer which only the part of the width of face of the magnetic sensitive part equivalent to the width of recording track was formed, and was formed in the both sides of that ferromagnetic layer, and this antiferromagnetism layer The magneto-resistive effect mold sensor according to claim 1 to 3 characterized by coming to impress vertical bias by the freed ferromagnetic layer in said flux reversal.

[Claim 6] The magneto-resistive effect mold sensor according to claim 5 characterized by the ferromagnetic layer by which the laminating was carried out to the 2nd antiferromagnetism layer for said vertical bias impression consisting of an amorphous thin film.

[Claim 7] The magneto-resistive effect mold sensor according to claim 1 to 6 characterized by the antiferromagnetism layer for impressing said vertical bias consisting of a X-Mn (however, X showing one-sort [in Fe, Co, nickel, Cr, Pt, Pd, Ir, Ru, and Rh], or two sorts or more.) system alloy thin film.

[Claim 8] The magnetic head characterized by coming to have a magneto-resistive effect mold sensor according to claim 1 to 7.

[Claim 9] While induction of the flux reversal which adjoins the 2nd antiferromagnetism layer for said vertical bias impression is carried out to the ferromagnetic layer freed in the manufacture approach of a magneto-resistive effect mold sensor according to claim 4, the magnetic anisotropy of tropism [whether the ferromagnetic layer is formed impressing a field and] Or it is made to be generated by heat-treating in a field after the ferromagnetic stratification. The manufacture approach of the magneto-resistive effect mold sensor characterized by what the magnetization process performed after the process which determines the direction of the magnetic anisotropy of a ferromagnetic layer where said flux reversal is freed in the magnetization direction of a ferromagnetic layer where pinning of the flux reversal which adjoins a coercive force increase layer is carried out determines.

[Claim 10] While induction is carried out to the ferromagnetic layer which adjoins the 2nd antiferromagnetism layer for said vertical bias impression, and constitutes a layered product in the manufacture approach of a magneto-resistive effect mold sensor according to claim 5, the magnetic anisotropy of tropism [whether the ferromagnetic layer is formed impressing a field and] Or it is made to be generated by heat-treating in a field after the ferromagnetic stratification. The manufacture approach of the magneto-resistive effect mold sensor characterized by what the magnetization process which performs the magnetization direction of a ferromagnetic layer where pinning of the flux reversal which adjoins a coercive force increase layer is carried out after the process which determines the direction of the magnetic anisotropy of the ferromagnetic layer of said layered product determines.

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DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[Field of the Invention] This invention relates to the magnetic head equipped with the sensor using the magneto-resistive effect component applied to the magnetic head, a position sensor, a rotation sensor, etc., its manufacture approach, and its sensor.

[0002]

[Description of the Prior Art] Conventionally, the AMR (Anisotropic Magnetoresistance) head using the anisotropy magneto-resistive effect phenomenon as a magneto-resistive effect mold reading head (MR head) and the GMR (Giant Magnetoresistance: giant magneto-resistance) head using the spin dependence scattering phenomenon of conduction electron are known, and the spin bulb (Spin-Valve) head which shows a high magneto-resistive effect by the low external magnetic field is shown in the U.S. Pat. No. 5159513 specification as one example of a GMR head. Drawing 10 and drawing 11 are drawings showing the outline configuration of AMR head component structure. If it is in the head component shown in drawing 10, the laminating of the electric insulation layer 2 and the ferromagnetic layer (AMR ingredient layer) 3 is carried out on the soft magnetism layer 1, spacing equivalent to the width of recording track is opened on the both ends of the ferromagnetic layer 3, the laminating of the antiferromagnetism layers 4 and 4 is carried out, further, on them, the laminating of the conductive layer 5 is carried out, and it is constituted. If it is in the head component shown in drawing 11, the laminating of the soft magnetism layer 1, the electric insulation layer 2, and the ferromagnetic layer 3 is carried out, and a layered product is constituted, and the magnet layers 6 and 6 are formed so that a layered product may be inserted into the both sides of this layered product, a conductive layer 5 is formed on the magnet layer 6, and it is constituted.

[0003] For the optimal actuation of this kind of AMR head, two bias fields are needed to the ferromagnetic layer 3 which shows the AMR effectiveness. The 1st bias field is for carrying out the linearity response of the resistance change of the ferromagnetic layer 3 to the magnetic flux from a magnetic medium, and to the field of a magnetic medium, this 1st bias field is perpendicularly (Z direction of drawing 1), and is made parallel to the film surface of the ferromagnetic layer 3. Usually, this 1st bias field is called horizontal bias, and can be acquired by passing a detection current for an AMR head component from a conductive layer 5. The 2nd bias field is called vertical bias and is usually impressed to parallel (the direction of X of drawing 1) to the film surface of a magnetic medium and the ferromagnetic layer 3. The purpose of this vertical bias field is for making it little smooth resistance change of a noise to this magnetic flux from controlling the Barkhausen noise produced when the ferromagnetic layer 3 forms many magnetic domains, i.e., a magnetic medium.

[0004] By the way, in order to control the aforementioned Barkhausen noise, it is required to single-domain-ize the ferromagnetic layer 3, and two kinds of approaches are usually learned by the impression approach of the vertical bias for it. It is the approach of the head component structure shown in drawing 11 being used for the 1st approach, arranging the magnet layers 6 and 6 on both sides of the ferromagnetic layer 3, and using the leakage flux from the magnet layer 6, and the 2nd approach is an approach of using the exchange anisotropy field which adopts the head component structure shown in drawing 10, and is produced in the contact interface of the antiferromagnetism layer 4 and the ferromagnetic layer 3.

[0005] And the thing using exchange anisotropy association by said antiferromagnetism layer of the exchange bias method shown in drawing 12 as component structure and the thing of the spin bulb method shown in drawing 13 are known. Drawing 12 is the structure which is similar to the structure shown in drawing 10 , carried out the laminating of the ferromagnetic layer 22, a non-magnetic layer 23, and the ferromagnetic layer 24 that does a magneto-resistive effect so, opened spacing equivalent to the width of recording track TW on the lower insulating layer 21, formed the antiferromagnetism layers 25 and 25 and the lead layers 26 and 26, and formed the up insulating layer 27 on them. In the structure shown in drawing 12 , vertical bias is given to the ferromagnetic layer 24, area B (field where the ferromagnetic layer 24 and the ferromagnetic layer 25 contacted) of drawing 12 is single-domain-ized by exchange anisotropy association in the interface of both the layers of the ferromagnetic layer 24 and the antiferromagnetism layer 25 in the direction of X, it is induced by this and the ferromagnetic layer 24 is single-domain-ized in the direction of X in the area A in the width of recording track. The stationary current is given to the ferromagnetic layer 24 through the antiferromagnetism layer 25 from the lead layer 26. If the stationary current is given to the ferromagnetic layer 24, the horizontal bias field to a Z direction will be given into the ferromagnetic layer 24 by the magnetostatic binding energy from the ferromagnetic layer 22. Thus, if the leakage field from a magnetic medium is given to the ferromagnetic layer 24 magnetized by the vertical bias field and the horizontal bias field, since the electric resistance over the stationary current will carry out a linearity response and it will change in proportion to the magnitude of this leakage field, a leakage field is detectable with change of this electric resistance.

[0006] On the lower insulating layer 21, the structure shown in drawing 13 carries out the laminating of the free ferromagnetism layer 28 and the nonmagnetic conductive layer 29 which constitute the magneto-resistive effect component 19, and the ferromagnetic layer 24, further, carries out the laminating of the antiferromagnetism layer 25 and the up insulating layer 27 one by one on the ferromagnetic layer 24, and is constituted. The stationary current is given to the magneto-resistive effect component 19 in the structure shown in drawing 13 . Magnetization of the ferromagnetic layer 24 is fixed to a Z direction by exchange anisotropy association with the antiferromagnetism layer 25, and if the leakage field from the magnetic medium which moves in the direction of Y is given, since the electric resistance of the magneto-resistive effect component 19 will change with change of the magnetization direction of the free ferromagnetism layer 28, the leakage field of a magnetic medium is detectable with change of this electric resistance.

[0007] As a configuration for adopting said spin bulb structure and on the other hand, carrying out optimal actuation of the above-mentioned structure As shown in the structure which carried out the laminating of the free ferromagnetism layer 7, the nonmagnetic interlayer 8, the pinning ferromagnetism layer 9, and the antiferromagnetism layer 10 as shown in drawing 14 , formed the magnet layers 11 and 11 in the both sides of this layered product, and formed the conductive layer 12 on it, or drawing 15 The laminating of the free ferromagnetism layer 7, the nonmagnetic interlayer 8, the pinning ferromagnetism layer 9, and the antiferromagnetism layer 10 is carried out, the both sides of a layered product are inserted in a conductive layer 12 and the antiferromagnetism layer 13 from the upper and lower sides, and the structure where these whole was made to adjoin a buffer layer 14 is known.

[0008] While the bias of the direction of a truck (the direction of X of drawing 14) is impressed in the magnet layers 11 and 11 at the free ferromagnetism layer 7 as it is the structure shown in drawing 14 , and making magnetization turned in the direction of a truck in the condition of having single-domain-ized It is necessary to make it turn to the Z direction in drawing, where bias is impressed and single-domain-ized in the direction which intersects perpendicularly the magnetization direction of the pinning ferromagnetism layer 9 with the Z direction in drawing 14 , i.e., the magnetization direction of the free ferromagnetism layer 7. That is, when the magnetization direction of said pinning ferromagnetism layer 9 must not change and the direction of the free ferromagnetism layer 7 changes with the magnetic flux (Z direction of drawing 14) from a magnetic medium in the range of 90° to the magnetization direction of the pinning ferromagnetism layer 9, the linearity responsibility of a magneto-resistive effect is acquired.

[0009] In order to make the magnetization direction of said pinning ferromagnetism layer 9 fix to the Z direction of drawing 14 and drawing 15 , a comparatively big bias field is required, and the more this bias field is large, the more it will be good. In order to overcome the anti-field of the Z direction of drawing 14 and drawing 15 and for the magnetization direction not to shake by the magnetic flux from a magnetic medium, the bias field of 100 Oe is required at least. If it is in the structure shown in drawing 14 and drawing 15 as an approach for acquiring this bias field, the exchange anisotropy field produced by contacting the antiferromagnetism layer 10 in the pinning ferromagnetism layer 9, and preparing it in it is used.

[0010] Moreover, the bias impressed to the free ferromagnetism layer 7 formed the magnet layer 11 in the both sides of the free ferromagnetism layer 7 in the structure shown, the approach are and same as the vertical bias in the AMR head, i.e., drawing 14 , for controlling the Barkhausen noise produced from forming the purpose for securing linearity responsibility, and many magnetic domains, and the approach of using the leakage flux from the magnet layer 11 as bias has been used for it. Moreover, in the structure shown in drawing 15 , the antiferromagnetic substance layer 13 was formed in the both-ends side of the free ferromagnetism layer 7, and the approach of using as bias the exchange anisotropy field produced in the contact interface of the free ferromagnetism layer 7 and the antiferromagnetism layer 13 is adopted.

[0011] As mentioned above, by using for the vertical bias in the case of the AMR head, the bias of the pinning ferromagnetism layer in the case of a spin valve head, and the bias of a free ferromagnetism layer the exchange anisotropy field produced in a contact interface with an antiferromagnetism layer, linearity responsibility is good and the magneto-resistive effect mold head which controlled the Barkhausen noise is realized.

[0012]

[Problem(s) to be Solved by the Invention] By the way, said exchange anisotropy field is a phenomenon resulting from the exchange interaction between the magnetic moments of the both sides in the contact interface of a ferromagnetic layer and an antiferromagnetism layer, and the FeMn layer is well known as a ferromagnetic layer, for example, an antiferromagnetism layer which produces an exchange anisotropy field with a NiFe layer. However, corrosion resistance is remarkably bad, corrosion advances during the production process of the magnetic head, and magnetic-head actuation, and a FeMn layer has the problem on which an exchange anisotropy field deteriorates greatly, and the problem which damages a magnetic medium depending on the case. Moreover, although going up easily to about 120 degrees C by generation of heat by the stationary detection current is known, the temperature near [under magnetic-head actuation] the FeMn layer The exchange anisotropy field by the FeMn layer has the problem from which the stable exchange anisotropy field is not acquired, in order that an exchange anisotropy field may decrease almost linearly to temperature until it is very sensitive and disappears at the temperature of about 150 degrees C to a temperature change (blocking temperature: Tb).

[0013] Although there is the NiMn alloy or NiMnCr alloy which has the face-centered tetragon structure shown for example, in the publication-number No. 76247 [six to] official report on the other hand as invention which has improved the corrosion resistance of the FeMn film and blocking temperature, although the corrosion resistance of a NiMn layer is better than the corrosion resistance of a FeMn layer, it is inadequate practically. Moreover, in order that a NiMnCr layer may raise the corrosion resistance of a NiMn layer, it is the alloy layer which added Cr, but although corrosion resistance improves by Cr addition, there is a problem to which the magnitude and blocking temperature of an exchange anisotropy field fall.

[0014] moreover , since the ordered structure crystal of the CuAg-I type which have face-centered tetragon (fct) structure in a part of antiferromagnetism layer must be form in order to acquire an exchange anisotropy field in a NiMn alloy or a NiMnCr alloy , and control of order disorder transformation and control of the rate of a volume ratio of a regulation phase and an irregular phase be naturally needed , in order to acquire the stable property , there be a problem to which the process control and management in a production process of the magnetic head cannot but become very complicated . Moreover, that heat treatment among a field must be repeated two or more times in order to acquire the exchange anisotropy field needed, and in order to lower a temperature fall rate from looseness, for example, 255 degrees C, to 45 degrees C, there was a problem to which it is about the problem which requires 17 hours

(Appl.Phys.Lett.65(9) 29 August 1994 reference), the processing time in a production process becomes long, and manufacture effectiveness worsens.

[0015] Moreover, a NiFe/FeMn cascade screen is heat-treated at the temperature of 260–350 degrees C as invention which improves the blocking temperature of a FeMn layer for 20 to 50 hours. Although the approach of forming nickel–Fe–Mn the alloy layer of 3 yuan in a NiFe/FeMn interface by diffusion by heat treatment is shown in the U.S. Pat. No. 4809109 specification By this approach, while being able to understand that there is no effectiveness in corrosion resistance improvement which is the greatest trouble of a FeMn layer, there is a problem on which required heat treatment time amount reduces manufacture effectiveness from a ***** extremely with 20 – 50 hours. On the other hand, although the ingredient of Mn system alloy, for example, NiMn, PtMn, AuMn, and RhMn3 grade is shown as an antiferromagnetism ingredient in the existing publication, for example, the “magnetic–substance handbook” of the Asakura Publishing issue There is no comment about the exchange anisotropy field in a ferromagnetic layer and a contact interface, and thickness is completely still more unknown about the own property and own exchange anisotropy field of an antiferromagnetism layer in the ultra–thin film of several 100A.

[0016] Furthermore, the sense of magnetization of the truck close to the magnet layers 11 and 11 and the section (field shown in drawing 14 with a sign 16) tended to become the insensible field which does not change easily, and if it was in the free ferromagnetism layer 7 to which bias was impressed by the magnet layers 11 and 11 on either side, when further ** truck–ization accompanying improvement in the recording density of a magnetic medium was advanced, there was a possibility might produce a problem, in the component structure shown in drawing 14 . For this reason, although the component structure using the switched connection bias shown in drawing 15 could become promising, when it was going to impress vertical bias to the component structure of spin bulb structure with a switched connection bias method, there were the following problems.

[0017] In the spin bulb component structure shown in drawing 15 , the antiferromagnetism layer 10 fixes rotation of magnetization of the pinning ferromagnetism layer 9, on the other hand, the antiferromagnetism layers 13 and 13 fix the sense of magnetization of the truck of the free ferromagnetism layer 7, and the section for vertical bias, and 90 degrees of sense of the magnetization which the antiferromagnetism layer 10 and the antiferromagnetism layer 13 should fix, respectively differ. In order to control the direction of magnetization of each magnetic film here, controlling the magnetization direction of the antiferromagnetism layer 10 which forms membranes later, without disturbing the direction of magnetization of the antiferromagnetism layer 13 which formed membranes first, although membrane formation–among field processing and the annealing treatment in a magnetic field after membrane formation are performing usually has a very difficult problem. Moreover, although the technique which solves said problem by using properly the magnetic film with which Neel temperature differs like a publication on publication–number No. 45032 [eight to] specifications, and changing heat treatment temperature into them for every magnetic film is indicated, since it is necessary to use a Fe–Mn alloy with low Neel temperature also with this technique, the fault in the corrosion resistance above–mentioned field and a fault sensitive to the temperature change resulting from blocking temperature have an unsolvable problem.

[0018] It is excellent in linearity responsibility and aims at offering the magneto–resistive effect mold sensor which controlled the Barkhausen noise while this invention was made in view of said situation, can be excellent in corrosion resistance and can impress required sufficient exchange anisotropy field in a thin film. Moreover, by offering an antiferromagnetism layer with high blocking temperature, after excelling in linearity responsibility, it is strong to a temperature change, and this invention aims at offering the magneto–resistive effect mold sensor which controlled the Barkhausen noise. Furthermore, it also aims heat treatment time amount at offering the manufacture approach which can be shortened conventionally while in manufacturing the magneto–resistive effect mold sensor which has the property which was excellent in the above–mentioned this invention does not have the need of performing heat treatment among a magnetic field for a long time using a special thermal treatment equipment and being able to manufacture it by the usual heat treatment.

[0019]

[Means for Solving the Problem] In order that this invention may solve said technical problem, a two-layer ferromagnetic layer at least It is generated through a non-magnetic layer, coercive force is enlarged by the coercive force increase layer which one side becomes from the 1st antiferromagnetic substance which adjoined the ferromagnetic layer and was prepared among said ferromagnetic layers, and pinning of the flux reversal is carried out. It is the magneto-resistive effect mold sensor by which it comes to free flux reversal of the ferromagnetic layer of another side. It comes to carry out contiguity arrangement of the 2nd antiferromagnetism layer which consists of the antiferromagnetic substance with which said flux reversal impresses vertical bias to this ferromagnetic layer, on the other hand, carries out induction of the magnetic anisotropy of tropism to the ferromagnetic layer which it comes to free, and stabilizes a magnetic domain. Next, in this invention, it is desirable to come mutually to carry out the abbreviation rectangular cross of magnetization of the ferromagnetic layer to which pinning of said flux reversal was carried out, and the magnetization of the ferromagnetic layer by which magnetization was freed in the condition that there is no external magnetic field. Furthermore, in this invention, it is desirable to come it larger than the exchange bias field of the one direction as for which induction is carried out to a ferromagnetic layer by alpha-Fe 2O3 at coincidence to carry out coercive force of the ferromagnetic layer by which pinning was carried out to this coercive force increase layer in flux reversal by said coercive force increase layer consisting of alpha-Fe 2O3.

[0020] In this invention, it is also desirable that the 2nd antiferromagnetism layer for said vertical bias impression opens the predetermined width of recording track equivalent to the width of face of a magnetic sensitive part in the both-ends side of the magnetic sensitive part of a ferromagnetic layer where it comes to free the aforementioned flux reversal, and comes to carry out opposite arrangement in contact with a ferromagnetic layer. In this invention, it is desirable that a layered product with other ferromagnetic layers by which the laminating was carried out to the antiferromagnetism layer by which only the part of the width of face of the magnetic sensitive part equivalent to the width of recording track was formed, and the ferromagnetic layer freed in said flux reversal was formed in the both sides of that ferromagnetic layer, and this antiferromagnetism layer comes to impress vertical bias by the freed ferromagnetic layer in said flux reversal. Furthermore, it is desirable that the ferromagnetic layer by which a laminating is carried out to the 2nd antiferromagnetism layer for said vertical bias impression consists of an amorphous thin film. Moreover, it is desirable that the antiferromagnetism layer for impressing said vertical bias consists of a X-Mn (however, X shows one-sort [in Fe Co, nickel, Cr, Pt, Pd, Ir, Ru, and Rh] or two sorts or more.) system alloy thin film. And this invention offers the magnetic head which comes to prepare the magneto-resistive effect mold sensor of the configuration of a publication for said either.

[0021] When manufacturing said magneto-resistive effect mold sensor of a configuration of that the 2nd antiferromagnetism layer for said vertical bias impression opens the predetermined width of recording track equivalent to the width of face of a magnetic sensitive part in the both-ends side of the magnetic sensitive part of a ferromagnetic layer where it comes to free the aforementioned flux reversal, and, on the other hand, comes to carry out opposite arrangement in contact with a ferromagnetic layer While induction of the flux reversal which adjoins the 2nd antiferromagnetism layer for said vertical bias impression is carried out to the ferromagnetic layer freed, the magnetic anisotropy of tropism [whether the ferromagnetic layer is formed impressing a field and] Or it is made to be generated by heat-treating in a field after the ferromagnetic stratification. It is desirable to determine according to the magnetization process performed after the process which determines the direction of the magnetic anisotropy of a ferromagnetic layer where said flux reversal is freed in the magnetization direction of a ferromagnetic layer where pinning of the flux reversal which adjoins a coercive force increase layer is carried out.

[0022] Moreover, only the part of the width of face of the magnetic sensitive part by which the ferromagnetic layer freed in said flux reversal is equivalent to the width of recording track is formed. When manufacturing said magneto-resistive effect mold sensor of a configuration of that the layered product of the antiferromagnetism layer of the antiferromagnetic substance formed

in the both sides of the ferromagnetic layer and other ferromagnetic layers comes to impress vertical bias. On the other hand, that induction is carried out to the ferromagnetic layer which adjoins an antiferromagnetism layer and constitutes a layered product the magnetic anisotropy of tropism [whether while impressing a field, forms the ferromagnetic layer, and] Or it is desirable to determine according to the magnetization process which performs the magnetization direction of a ferromagnetic layer where pinning of the flux reversal which is produced by heat-treating in a field after the ferromagnetic stratification, and adjoins a coercive force increase layer is carried out after the process which determines the direction of the magnetic anisotropy of the ferromagnetic layer of said layered product.

[0023]

[Embodiment of the Invention] With reference to a drawing, one gestalt of this invention is explained below. Drawing 1 is what shows one gestalt of the magneto-resistive effect mold sensor concerning this invention. On the coercive force increase layer 31, the laminating of the ferromagnetic layer 32, a non-magnetic layer 33, and the ferromagnetic layer 34 is carried out one by one. While opening spacing equivalent to the width of recording track TW between mutual on the both ends of the ferromagnetic layer 34, carrying out the laminating of the antiferromagnetism layers 35 and 35 and carrying out the laminating of the lead layer 36 on the antiferromagnetism layer 35, the lead layer 36 and the ferromagnetic layer 34 are covered, and the laminating of the up insulating layer 37 is carried out. In addition, in the structure of this gestalt, the magneto-resistive effect component 30 of a spin bulb mold is constituted by the coercive force increase layer 31, the ferromagnetic layer 32, a non-magnetic layer 33, and the ferromagnetic layer 34.

[0024] Said coercive force increase layer 31 makes the magnetic switched connection force act on the ferromagnetic layer 32 formed on it, and increases the coercive force of the ferromagnetic layer 32, and it is for carrying out pinning of the sense of magnetization, as for this coercive force increase layer 31, it is desirable to consist of the antiferromagnetic substance, especially the oxide antiferromagnetic substance, and it is formed from alpha-Fe 2O3 as one example. Although said ferromagnetic layers 32 and 34 all consist of a thin film of a ferromagnetic, they specifically consist of a nickel-Fe alloy, a Co-Fe alloy, a nickel-Co alloy, Co, a nickel-Fe-Co alloy, etc. Moreover, Co layer to the ferromagnetic layer 34 can also consist of a nickel-Fe alloy layer or a laminated structure of Co layer and a nickel-Fe alloy layer for the ferromagnetic layer 32. In addition, when considering as the two-layer structure of Co layer and a nickel-Fe alloy layer, it can also consider as the structure which arranges thin Co layer to a non-magnetic layer 33 side.

[0025] Possibility that factors other than spin dependence dispersion of conduction electron will arise is low, and it originates in the ability of a higher magneto-resistive effect to be acquired rather than the direction where the effectiveness of spin dependence dispersion of conduction electron constitutes a large thing and the ferromagnetic layers 32 and 34 from an ingredient of the same kind according to the interface of Co and Cu consists of ingredients of a different kind, if this is in the giant magneto-resistance developmental mechanics of the structure whose non-magnetic layer 33 is pinched in the ferromagnetic layers 32 and 34. Since it is such, when the ferromagnetic layer 32 is constituted from Co, the structure which permuted the non-magnetic layer 33 side of the ferromagnetic layer 34 by Co layer by predetermined thickness is desirable. Moreover, even if distinguish especially Co layer and it does not prepare it, it is good also as a concentration gradient layer to which Co concentration becomes thin gradually as it considers as the alloy condition which there is much Co and was included in the non-magnetic layer 33 side of the ferromagnetic layer 34 and goes to the up protective layer 37 side.

[0026] Said non-magnetic layer 33 consists of non-magnetic material represented by Cu, Cr, Au, Ag, etc., and is formed in the thickness of 20-40A. If the thickness of a nonmagnetic membrane 33 is thinner than 20A here, magnetic association will become easy to take place between the ferromagnetic layer 32 and the ferromagnetic layer 34. Moreover, since the rate of the conduction electron scattered about by the interface of the non-magnetic layer 33 which is the factor which produces a magneto-resistive effect, and the ferromagnetic layers 32 and 34 will fall and a magneto-resistive effect will be reduced according to the shunt effect of a current if a non-magnetic layer 33 is thicker than 40A, it is not desirable.

[0027] As for the antiferromagnetism layer 31, it is [said antiferromagnetism layer 35] desirable to consist of the different antiferromagnetic substance, for example, the X-Mn alloy which has unordered structure. As for X, in said empirical formula, it is desirable to consist of any one sort of Ru, Rh, Ir, Pd, and the Pt or two sorts or more here. Although the aforementioned Mn system alloy has the irregular crystal structure, it means the condition that this irregular crystal structure is not the regular crystal structure like face-centered tetragons (fct superlattice; CuAuI structure etc.). namely, the elevated temperature for making Mn alloy in this invention into the regular crystal structures (CuAuI structure etc.), such as said face-centered tetragon, after membranes are formed by sputtering etc. -- and long duration is not heat-treated and the irregular crystal structure is a thing in a condition [being formed by the forming-membranes methods, such as sputtering,], or the condition that the usual annealing treatment was performed to this.

[0028] For ten to 45 atom %, and Rh, ten to 40 atom % and Ir are [the range where the content of X in case X of said X-Mn alloy is a single metal atom is desirable / Ru / ten to 25 atom % and Pt of ten to 40 atom % and Pd] ten to 25 atom %. In addition, all the upper limit minimums of the numerical range which 10 – 45 atom % means below 45 atom % in the above publication above 10 atom %, and is displayed by “–” shall be specified by the “above” and the “following.”

[0029] If it is the antiferromagnetism layer 35 of the X-Mn system alloy of said irregular crystal structure, vertical bias can be impressed to the ferromagnetic layer 34 by the one direction anisotropy, and pinning of the rotation of magnetization of the both ends of the ferromagnetic layer 34 which touches the ferromagnetic layer 35 can be carried out. Moreover, if it is the antiferromagnetism layer 35 of the alloy of said X-Mn system, compared with Fe-Mn of the conventional antiferromagnetism layer, it will excel in corrosion resistance, and fluctuation of the exchange anisotropy field (Hex) over a temperature change will decrease. Therefore, it is strong to a resistance to environment by using the antiferromagnetism layer 35, and it is hard to generate a noise at the time of detection of the leakage field from a magnetic medium, and becomes the thing in which high-definition magnetic detection is possible. Moreover, if it is the antiferromagnetism layer 35 of a X-Mn alloy, since heat-treatment of an elevated temperature and long duration is unnecessary, possibility of also producing the element diffusion between each magnetic layer in accordance with heating will be low, and problems, such as change of magnetic properties, degradation, or destruction of an insulating layer, will not be produced.

[0030] Said up protective layer 37 is a layer prepared for antioxidizing of the ferromagnetic layer 34 etc. in order to set up spacing (Gap) with an up shielding magnetic layer. Moreover, as for this up protective layer 37, it is desirable to constitute from insulating materials, such as aluminum 2O3 and a quartz.

[0031] Moreover, by forming the antiferromagnetism layer 35 on said ferromagnetic layer 34, the sense of magnetization can be arranged in the direction which gives an one direction anisotropy to the ferromagnetic layer 34, and is shown in the arrow head a of drawing 1, and bias can be impressed and single-domain-ized. Moreover, by the coercive force increase layer 31 stuck all over the ferromagnetic layer 32, pinning of the sense of magnetization of the ferromagnetic layer 32 can be carried out, and the sense of magnetization can be arranged in the direction perpendicular to the space of drawing 1 of b. By turning the sense of magnetization of the ferromagnetic layer 34 in the direction of arrow-head a of drawing 1 and drawing 2, and turning the sense of the ferromagnetic layer 32 in the direction of arrow-head b from the above thing, both can be made to be able to intersect perpendicularly at about 90 degrees, and can be arranged.

[0032] The stationary current is given to the magneto-resistive effect component 30 in the structure shown in drawing 1. If it is the structure shown in drawing 1, as a result of coercive force's increasing in response to magnetic switched connection, pinning of the sense of the magnetization being carried out by existence of the coercive force increase layer 31 and the ferromagnetic layer's 32 being freed in the field in which the direction of magnetization of other ferromagnetic layers 34 is equivalent to the width of recording track TW, a coercive force difference arises among the ferromagnetic layers 32 and 34, it originates in this, and giant magneto-resistance is obtained. That is, if external magnetic fields, such as a leakage field from the magnetic-recording medium which moves in the direction of Y, act on the part equivalent to

the width of recording track TW of the center section of the ferromagnetic layer 34 where rotation of magnetization was freed, since the sense of magnetization of the ferromagnetic layer 34 will rotate easily, resistance change arises for the magneto-resistive effect component 30 with rotation, and the magnetic information on a magnetic-recording medium can be read by measuring this resistance change. Moreover, resistance change is obtained by good linearity responsibility, without producing a Barkhausen noise, since the ferromagnetic layer 34 is single-domain-ized and vertical bias is moreover impressed in the case of this resistance change.

[0033] Moreover, in the structure shown in drawing 1, although the coercive force increase layer 31 was constituted from alpha-Fe 2O3, alpha-Fe 2O3 is an oxide from the first, and excellent in corrosion resistance compared with FeMn, and since Neel temperature is high, there is the description strong against temperature fluctuation. In addition, if it was in the component structure shown in drawing 1, the coercive force increase layer 31 was constituted from alpha-Fe 2O3, but be [what is necessary / just since it seems that the component of the coercive force increase layer 31 makes the magnetic switched connection force act on the ferromagnetic layer 32, and makes coercive force high], of course, you may constitute from other antiferromagnetic substance, oxide antiferromagnetic substance, or high coercive force magnetic substance.

[0034] Next, drawing 3 shows other gestalten of the magneto-resistive effect sensor concerning this invention, and the laminating of the coercive force increase layer 41, the pinning ferromagnetism layer 42, a non-magnetic layer 43, and the free ferromagnetism layer 44 is carried out, the layered product 45 of cross-section trapezoidal shape is formed, the antiferromagnetism layers 46 and 46 are formed in the both sides of this layered product 45, and on each antiferromagnetism layer 46, the magneto-resistive effect sensor of this gestalt carries out the laminating of the ferromagnetic layer 47 and the conductive layer 48, and is constituted. In this gestalt, the antiferromagnetism layer 46 covers the flank of the antiferromagnetism layer 41, the pinning ferromagnetism layer 42, and a non-magnetic layer 43 in that edge 46a. Although the flank of the free ferromagnetism layer 44 is thickness-one-half-grade-covered, and it is prepared, and thickness one half covers the flank of the free ferromagnetism layer 44 and the ferromagnetic layer 47 on the antiferromagnetism layer 46 is formed at the edge, the thickness relation of each class is not restricted to what was shown in the drawing. Moreover, the thing which made reverse physical relationship of the upper and lower sides of the antiferromagnetism layer 46 and a ferromagnetic layer, or the thing which made the layered product of the antiferromagnetism layer 46 and the ferromagnetic layer 47 multistage pile structure may be used. A coercive-force increase layer 41 consists of an ingredient equivalent to the coercive-force increase layer 31 used in the previous example, the pinning ferromagnetism layer 42 consists of an ingredient equivalent to the ferromagnetic layer 32 used in the previous example, the nonmagnetic interlayer 43 consists of an ingredient equivalent to the non-magnetic layer 33 used in the previous example, and a free ferromagnetism layer 44 consists of an ingredient equivalent to the ferromagnetic layer 34 used in the previous example in the aforementioned structure. Moreover, the antiferromagnetism layer 46 consists of an ingredient equivalent to the antiferromagnetism layer 35 used in the previous example, and, as for the ferromagnetic layer 47, it is desirable to consist of a cascade screen of ferromagnetic layers, such as amorphous CoNbZr, CoFeB, and CoFeZr, and them, and crystalline substance film, such as a NiFe alloy.

[0035] In the structure shown in drawing 3, while carrying out pinning of the sense of magnetization of the ferromagnetic layer 47 in the direction of arrow-head a of drawing 3 by the one direction anisotropy of the antiferromagnetism layer 46, according to the sense of magnetization of the ferromagnetic layer 47, the sense of magnetization of the free ferromagnetism layer 44 can be guided in the direction of arrow-head a, and vertical bias can be impressed. Moreover, pinning of the sense of magnetization of the pinning ferromagnetism layer 42 is carried out in the direction of arrow-head b of drawing 3 by the coercive force increase layer 41. As mentioned above, while single-domain-izing the free ferromagnetism layer 44 and the ferromagnetic layer 47, the sense of magnetization of the free ferromagnetism layer 44 can be made to intersect perpendicularly to the sense of magnetization of the pinning ferromagnetism layer 42. Next, when the ferromagnetic layer 47 is constituted from an amorphous ferromagnetic, since the MR effectiveness is small, the ferromagnetic layer of an

amorphous substance has the advantage into which side leading (gather the field of a magnetic medium except the truck section) can introduce what has few distribution also for an one direction anisotropy few.

[0036] In the structure of this gestalt, resistance change is obtained by good linearity responsibility, without producing a Barkhausen noise like the structure of a previous gestalt, since vertical bias is impressed while being able to carry out [single domain]-izing of the free ferromagnetism layer 44.

[0037] Next, drawing 4 – drawing 6 show the example of 1 structure of the thin film magnetic head equipped with the component structure shown in drawing 1 or drawing 3 . Magnetic-head HA of this example is the thing of the surfacing type carried in a hard disk drive unit etc., and the side shown by (b) of drawing 4 by the leading side by which the side which shows the slider 51 of this magnetic-head HA by (b) of drawing 4 turns to the upstream of the migration direction of a disk side is a trailing side. In the field which counters the disk of this slider 51, the rail-like ABS sides 51a, 51a, and 51b and Ayr groove 51c are formed. And the thin film magnetic head 50 is formed in 51d of end faces by the side of trailing of this slider 51.

[0038] The thin film magnetic head 50 shown in this example is the compound-die magnetic head as shows cross-section structure to drawing 5 and drawing 6 , and on 51d of trailing side edge sides of a slider 51, the laminating of MR head (read head) h1 and the inductive head (write head) h2 is carried out to order, and it is constituted.

[0039] MR head h1 of this example detects the leakage flux from record media, such as a disk, using a magneto-resistive effect, and reads a magnetic signal. As shown in drawing 5 , the up gap layer 54 formed of non-magnetic materials, such as an alumina (aluminum 2O3), on the lower gap layer 53 which MR head h1 becomes from magnetic alloys, such as Sendust (Fe-aluminum-Si) formed in the trailing side edge section of a slider 51, is formed. And the laminating of the magneto-resistive effect mold sensor of the structure shown on this up gap layer 54 at drawing 1 or drawing 3 used as a giant magneto-resistance component is carried out. Furthermore, on it, the up gap layer which consists of an alumina etc. is formed, and the up shielding layer is formed on it, and let this up shielding layer at combination be the lower core layer 55 of the inductive head h2 formed on it.

[0040] The coil layer 66 patternized so that the gap layer 64 might be formed on the lower core layer 55 and an inductive head h2 might become spiral superficially on it is formed, and the coil layer 66 is surrounded by the insulating material layer 67. In the point 68a, the up core layer 68 formed on the insulating material layer 67 opens a minute gap in the lower core layer 55, counters it in ABS side 51b, connects the end face section 68b to the lower core layer 55 magnetically, and is prepared. Moreover, on the up core layer 68, the protective layer 69 which consists of an alumina etc. is formed.

[0041] In an inductive head h2, a record current is given to the coil layer 66 and a record current is given to a core layer from the coil layer 66. And a magnetic signal is recordable on record media, such as a hard disk, with the leakage field from the point of the lower core layer 55 in the part of magnetic gap G, and the up core layer 68. Moreover, in MR head h1, since resistance of the ferromagnetic layer 44 changes with the existence of the minute leakage field from record media, such as a hard disk, the contents of record of a record medium can be read by reading this resistance change. Furthermore, in magnetic-head HA of this configuration, since there is no Barkhausen noise, a resistance change excellent in linearity responsibility can be obtained, since the magneto-resistive effect mold sensor of structure explained previously is formed, and MR ratio higher than the further conventional magnetic head can be obtained, there is the description in which the read-out engine performance is excellent.

[0042] Next, in order to obtain the magneto-resistive effect mold sensor of the structure shown in drawing, substrates, such as aluminum2O3-TiC (Al Chick), are installed in the chamber of high frequency magnetron sputtering equipment or ion beam spatter equipment, and after making the inside of a chamber into inert gas ambient atmospheres, such as Ar gas, it can create by forming a required layer one by one. Targets required for membrane formation are 2Oalpha-Fe 3 target, a nickel-Fe alloy target, a Cu target, etc. Next, in order to manufacture the magneto-resistive effect mold sensor shown in drawing 3 concerning this invention Impressing a field at drawing 1 and the Z direction of 3 into the ambient atmosphere of 3 or less mTorr of Ar gas pressure While

forming the coercive force increase layer 41 which consists of alpha-Fe 2O3 on a substrate by the spatter and forming the two-layer ferromagnetic layers 42 and 44 on both sides of a non-magnetic layer 43 on this coercive force increase layer 41. It leaves the part which is equivalent to the width of recording track with a photolithography process and ion milling, other parts are removed, and it considers as a layered product 45. Next, laminating formation of the antiferromagnetism layer 46, the ferromagnetic layer 47 of an amorphous substance, and the electrode layer 48 is carried out by the spatter at a part for the both ends of said layered product 45, impressing a magnetic field in the aforementioned impression direction and the aforementioned direction of a right angle of a magnetic field. Subsequently, a field is impressed to the space perpendicular direction of drawing 3, and the pinning ferromagnetism layer 42 is magnetized. The magneto-resistive effect mold sensor of the structure shown in drawing 3 the sense of magnetization of the pinning ferromagnetism layer 42 and 90 degrees of drawing 3 and sense of magnetization of the ferromagnetic layer 44 crossed at right angles by the above processing can be obtained.

[0043] Moreover, in order to manufacture the magneto-resistive effect mold sensor of the structure shown in drawing 1, after carrying out the laminating of the coercive force increase layer 31, the ferromagnetic layer 32, a non-magnetic layer 33, and the ferromagnetic layer 34, the laminating of an antiferromagnetism layer and the conductive layer is carried out, and it forms in the condition except the central parts of a ferromagnetic layer and a conductive layer according to a photolithography process, and the up protective layer 37 is formed after that. Moreover, membranes are formed, impressing a field in the direction which corresponds in drawing 1 and the direction of X of 3, in case membranes are formed impressing a field in drawing 1 and the direction equivalent to the Z direction of 3 in case the coercive force increase layer 31 is formed at the time of formation of these each class and the antiferromagnetism layer 35 is formed. Subsequently, finally a field is impressed to the space perpendicular direction of drawing 1, and the pinning ferromagnetism layer 32 is magnetized. The magneto-resistive effect mold sensor of the structure shown in drawing 1 the sense of magnetization of the pinning ferromagnetism layer 32 and 90 degrees of drawing 1 and sense of magnetization of the ferromagnetic layer 34 crossed at right angles by the above processing can be obtained.

[0044]

[Example] Using RF magnetron sputtering equipment, on the aluminum2O3-TiC (Al Chick) substrate which covered 2Oaluminum3 film, the magneto-resistive effect mold sensor of the structure which carries out a spatter, creates a layered product and is shown in drawing 3 was manufactured so that it might become the structure which uses two or more targets and is shown below. Under the present circumstances, thickness of the protective layer which consists of 75A and Ta the thickness of the ferromagnetic layer which consists of 20A and nickel80Fe20 alloy the thickness of the non-magnetic layer which consists of 30A and Cu the ferromagnetic layer thickness which consists of 500A and nickel80Fe20 alloy the thickness of the coercive force increase layer which consists of alpha-Fe 2O3 was made into 30A. Moreover, to the substrate, in order to make it a pinning ferromagnetism layer have an anisotropy in the direction of arrow-head b of drawing 3, membranes were formed, impressing the field of 200 Oe in the direction of arrow-head b.

[0045] To the obtained layered product, leave a part with a width of recording track (width of face of a magnetic sensitive part) of 2 micrometers by the photolithography process and ion milling, and the both ends of a layered product are removed. The laminating of an antiferromagnetism layer (Pt50Mn50) with a thickness of 300A, an amorphous layer (Co88Nb8Zr4) with a thickness of 200A, and the electrode layer with a thickness of 700A is carried out to the both sides of this magnetic sensitive part that remained by the spatter. The field of 200 Oe was impressed in the direction different 90 degrees from the aforementioned impression field in the case of this laminating. Finally, patterning was carried out according to the FOTORISO process so that it might be set to width-of-recording-track [of 2 micrometers], and height (height of space thickness direction of drawing 3) 1micrometer, the field of 2kOe(s) was impressed in the height direction (the space thickness direction of drawing 3), and the pinning ferromagnetism layer was magnetized. Moreover, in advance of magnetization of the height direction, annealing in a field of 5 hours was given to some samples at 250 degrees C,

impressing a magnetic field crosswise [truck] (from the left of drawing 3 to the right).

[0046] The result of having measured the magnetic-reluctance curve in the low field of the magneto-resistive effect mold sensor sample obtained by the above manufacture approach is shown in Table 1 and drawing 7. In addition, the impression field was made into the above-mentioned height direction.

[0047]

[Table 1]

反強磁性層	抵抗変化率 (± 50 Oe)	直線性 (± 50 Oe)	ヒステリ シス	バルクハウ ゼンノイズ
Pt ₅₀ Mn ₅₀	3.1%	良好	無し	無し
Pd ₅₀ Mn ₅₀	3.6%	良好	無し	無し
Pd ₃₀ Pt ₂₀ Mn ₅₀	3.0%	良好	無し	無し
Ni ₅₀ Mn ₅₀	2.8%	良好	無し	無し
Ru ₅₀ Mn ₅₀	3.4%	良好	無し	無し
Cr ₅₂ Mn ₄₈	2.8%	良好	無し	無し
Fe ₅₁ Mn ₄₉	2.9%	良好	無し	無し
Ir ₁₅ Mn ₈₅	3.1%	良好	無し	無し
Rh ₂₀ Mn ₈₀	3.0%	良好	無し	無し

[0048] In drawing 7, it is mostly located in the middle point and the resistance in a zero field shows indirectly the thing of max and the minimum resistance which magnetization lies at right angles. Even if an external magnetic field changes by being mostly located in the middle point in the range which is **50 Oe extent, it has good linearity and it can be said that a dynamic range is large. Moreover, neither a hysteresis nor a Barkhausen noise was seen, but it became clear that a property suitable as the magnetic head for read-out was shown. Furthermore, the resistance rate of change in the range of **50 Oe is 3.1%, and it is clear that it is also high power very much. Moreover, although it replaced with PtMn, the sample using PdMn, PdPtMn, NiMn, RuMn, CrMn, FeMn, IrMn, and RhMn was also manufactured as an antiferromagnetism layer, respectively and measurement was presented similarly, it became clear to do so the effectiveness which was excellent as shown in Table 1.

[0049] Next, drawing 8 shows the blocking temperature Tb of the magneto-resistive effect mold sensor sample using alpha-Fe 2O3 which this invention persons have proposed in a Japanese-Patent-Application-No. No. 78022 [seven to] specification previously. Moreover, it replaced with the Japanese-Patent-Application-No. No. 78022 [seven to] specification at the sample and FeMn of structure using FeMn of the example structure of a comparison of a publication (the layered product of NiFe/Cu/NiFe/FeMn (110A), and layered product of NiFe/Cu/CoPt (80A)) for the comparison, and the temperature characteristic of the sample using NiO was also written together. Hbp says the bias field which the flux reversal of the NiFe film contiguous to the antiferromagnetism film shifts, and Hcp means the coercive force by the hysteresis here. It became clear that the magneto-resistive effect mold sensor sample using the result shown in drawing 8 to alpha-Fe 2O3 also has the outstanding thermal resistance. This is considered to originate in the Neel temperature (677 degrees C) of 2Oalpha-Fe 3 the very thing being high compared with FeMn or NiO. Therefore, if it is a magneto-resistive effect mold sensor sample using this alpha-Fe 2O3, a magneto-resistive effect mold sensor with little property degradation can be offered also by the temperature change.

[0050] Next, drawing 9 (A) shows the magnetic-reluctance curve of the spin bulb magneto-resistive effect mold sensor by which drawing 9 (B) used it for the magnetization curve of the pinning ferromagnetism layer which touched coercive force increase layers (alpha-Fe 2O3 etc.). In drawing 9 (A) and (B), the value of coercive force (Hc) and an exchange bias field (Hb) is shown, respectively, and serves as Hc>Hb here. On the other hand, in the ferromagnetic layer which touches the antiferromagnetism layer 46 of drawing 3, it becomes Hc<Hb conversely. In

this case, on the other hand, the anisotropy of tropism will have arisen, and it was defined as on the other hand the anisotropy of tropism having arisen about the ferromagnetic layer used as such relation on these specifications.

[0051]

[Effect of the Invention] If what consists of an amorphous thin film is used for this invention as a ferromagnetic layer made to adjoin the magneto-resistive effect component of a magnetic sensitive part as explained above, since the MR effectiveness is small, the ferromagnetic layer of an amorphous substance can introduce few things of distribution of an one direction anisotropy that there is little side leading (gather the field of a magnetic medium except the truck section).

[0052] It is using what consists of a X-Mn (however, X's shows one-sort [in Fe, Co, nickel, Cr, Pt, Pd, Ir, Ru, and Rh], or two sorts or more.) system alloy thin film as an antiferromagnetism layer for impressing vertical bias, and it excels in corrosion resistance and what has a small change of the exchange anisotropy field by the temperature change can be offered. Moreover, since it can be used even if it does not perform special heat treatment in the condition [having formed membranes by the forming-membranes methods, such as sputtering,] if it is the presentation range with a X-Mn system alloy, heat treatment conditions can be conventionally eased from structure.

[0053] Next, if the magneto-resistive effect sensor of said structure is used for the magnetic head, the magnetic head which carries out a linearity response and can carry out read-out of a lifting and the magnetic information which does not have a Barkhausen noise with sufficient detection sensitivity by this for resistance change to a minute field from a magnetic-recording medium can be offered.

[0054] While induction of the flux reversal which adjoins the antiferromagnetism layer for vertical bias impression is carried out to the ferromagnetic layer freed, next, the magnetic anisotropy of tropism [whether the ferromagnetic layer is formed impressing a field and] Or it is made to be generated by heat-treating in a field after the ferromagnetic stratification. By determining according to the magnetization process performed after the process which determines the direction of the magnetic anisotropy of a ferromagnetic layer where said flux reversal is freed in the magnetization direction of a ferromagnetic layer where pinning of the flux reversal which adjoins a coercive force increase layer is carried out The sense of magnetization of the ferromagnetic layer to which pinning of the flux reversal was carried out, and the sense of magnetization of the ferromagnetic layer by which flux reversal was freed can be made to be able to intersect perpendicularly mostly, and the magneto-resistive effect mold sensor which moreover impressed vertical bias can be obtained.

[0055] While induction is carried out to the ferromagnetic layer which adjoins an antiferromagnetism layer and constitutes a layered product, tropism furthermore, a magnetic anisotropy It is made to be generated by forming the ferromagnetic layer, impressing a field, or heat-treating in a field after the ferromagnetic stratification. By determining according to the magnetization process which performs the magnetization direction of a ferromagnetic layer where pinning of the flux reversal which adjoins a coercive force increase layer is carried out after the process which determines the direction of the magnetic anisotropy of the ferromagnetic layer of said layered product The sense of magnetization of the ferromagnetic layer to which pinning of the flux reversal was carried out, and the sense of magnetization of the ferromagnetic layer by which flux reversal was freed can be made to be able to intersect perpendicularly mostly, and, moreover, the magneto-resistive effect mold sensor which impressed vertical bias can be obtained.

[0056] Moreover, since flux reversal prepared the antiferromagnetism layer of the antiferromagnetic substance which is made to carry out induction of the magnetic anisotropy of an one direction to the ferromagnetic layer which it comes to free, and stabilizes a magnetic domain in this invention A ferromagnetic layer can be single-domain-ized and resistance change can be produced by changing the direction of the flux reversal of a ferromagnetic layer with the direction of the magnetization of a ferromagnetic layer by which pinning was carried out by the external magnetic field. A Barkhausen noise can be abolished while an external magnetic field is detectable with sufficient sensibility with this resistance change. Moreover, field detection which was excellent in linearity responsibility can be performed by single-domain-izing a ferromagnetic

layer. Furthermore, when 90 degrees of sense of magnetization of the ferromagnetic layer by which magnetization and magnetic reversal of the ferromagnetic layer to which pinning of the flux reversal was carried out were freed differ, an efficient big magnetic-reluctance change can be obtained. Moreover, if it considers as the antiferromagnetism layer which carries out pinning of the sense of magnetization and the layer of alpha-Fe 2O3 is used, it originates in the Neel temperature of alpha-Fe 2O3 being high, and it is strong to a thermal change and the magneto-resistive effect mold sensor to which detection sensitivity does not fall by the thermal change can be offered.

[0057] By next, the thing which the antiferromagnetism layer for vertical bias impression opens the predetermined width of recording track equivalent to the width of face of a magnetic sensitive part in the both-ends side of the magnetic sensitive part of a ferromagnetic layer where it comes to free flux reversal, and comes to do opposite arrangement in contact with a ferromagnetic layer While being able to impress vertical bias to the both sides of the magnetic sensitive part of a ferromagnetic layer by the magnetic anisotropy of tropism on the other hand, resistance change can be obtained in the condition that vertical bias is impressed by making easy flux reversal of the magnetic sensitive part of a ferromagnetic layer, and there is no Barkhausen noise with sufficient linearity responsibility.

[0058] Next, only the part of the width of face of the magnetic sensitive part by which the ferromagnetic layer freed in flux reversal is equivalent to the width of recording track is formed. By the layered product of the antiferromagnetism layer of the antiferromagnetic substance formed in the both sides of the ferromagnetic layer and other ferromagnetic layers coming to impress vertical bias While being able to impress vertical bias to a ferromagnetic layer by the magnetic anisotropy of tropism on the other hand, resistance change can be obtained in the condition that vertical bias is impressed by making flux reversal of a ferromagnetic layer easy, and there is no Barkhausen noise with sufficient linearity responsibility.

[Translation done.]

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DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]

[Drawing 1] The sectional view showing the 1st gestalt of the magneto-resistive effect mold sensor concerning this invention.

[Drawing 2] Drawing showing the sense of magnetization of each ferromagnetic layer of the sensor shown in drawing 1.

[Drawing 3] The sectional view showing the 2nd gestalt of the magneto-resistive effect mold sensor concerning this invention.

[Drawing 4] The perspective view of the thin film magnetic head equipped with the magneto-resistive effect mold sensor concerning this invention.

[Drawing 5] The sectional view of the important section of the thin film magnetic head shown in drawing 4.

[Drawing 6] The perspective view which made the cross section a part of thin film magnetic head shown in drawing 4.

[Drawing 7] Drawing showing the resistance change curve of an example sample.

[Drawing 8] Drawing showing the blocking temperature of the magneto-resistive effect mold sensor sample using alpha-Fe 2O3.

[Drawing 9] It is drawing in which drawing 9 (A) shows the magnetization curve of a pinning ferromagnetism layer, and drawing 9 (B) shows the magnetic-reluctance curve of a magneto-resistive effect mold sensor.

[Drawing 10] The sectional view showing the 1st example of the conventional magneto-resistive effect mold sensor.

[Drawing 11] The sectional view showing the 2nd example of the conventional magneto-resistive effect mold sensor.

[Drawing 12] The sectional view showing the 3rd example of the conventional magneto-resistive effect mold sensor.

[Drawing 13] The sectional view showing the 4th example of the conventional magneto-resistive effect mold sensor.

[Drawing 14] The sectional view showing the 5th example of the conventional magneto-resistive effect mold sensor.

[Drawing 15] The sectional view showing the 6th example of the conventional magneto-resistive effect mold sensor.

[Description of Notations]

30 Magneto-resistive Effect Component

31 41 Coercive force increase layer

32 Ferromagnetic Layer

33 43 Non-magnetic layer

34 Ferromagnetic Layer

35 Antiferromagnetism Layer

36 Lead Layer

42 Pinning Ferromagnetism Layer

44 Free Ferromagnetism Layer

46 Antiferromagnetism Layer

47 Ferromagnetic Layer

48 Conductive Layer

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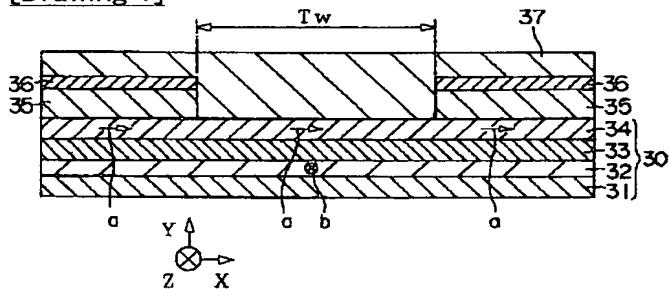
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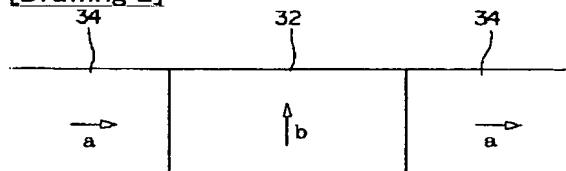
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DRAWINGS

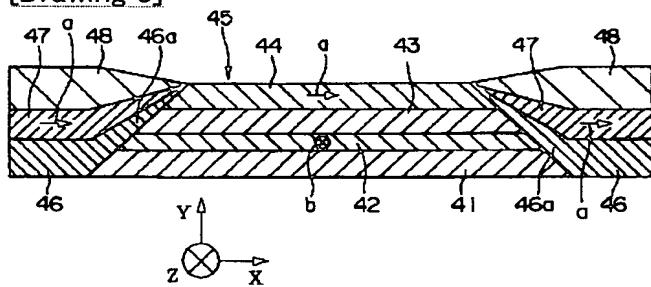
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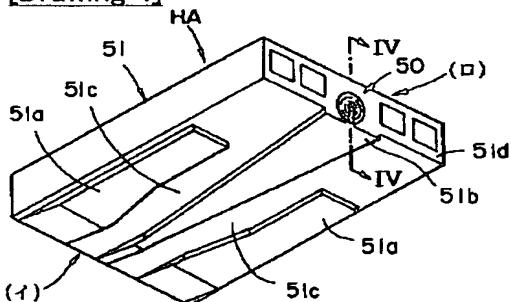
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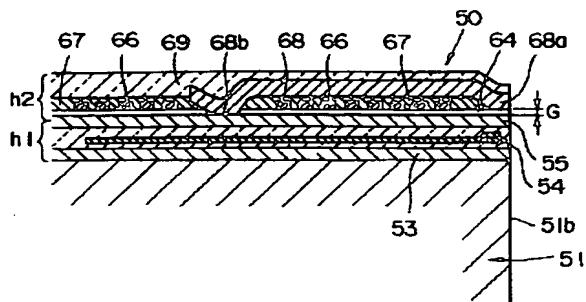
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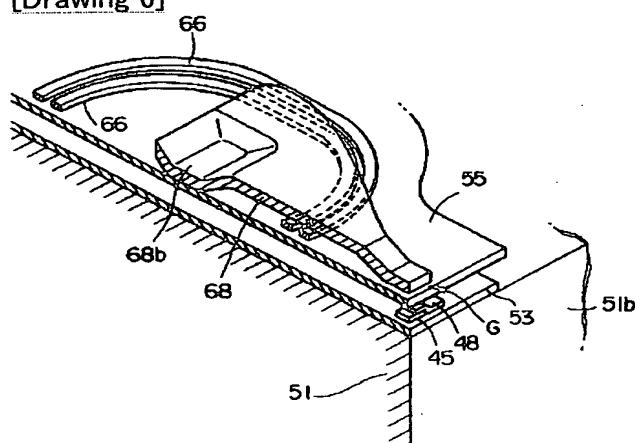
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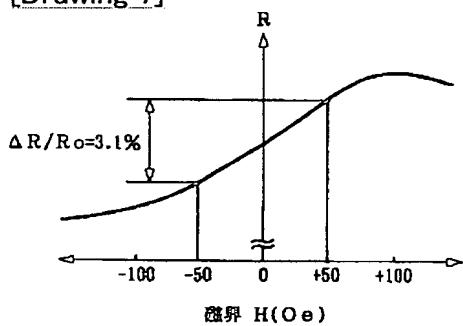
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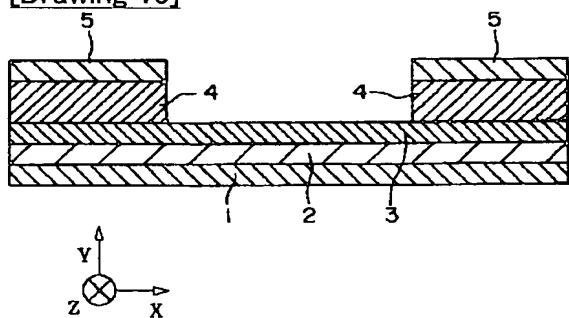
[Drawing 6]



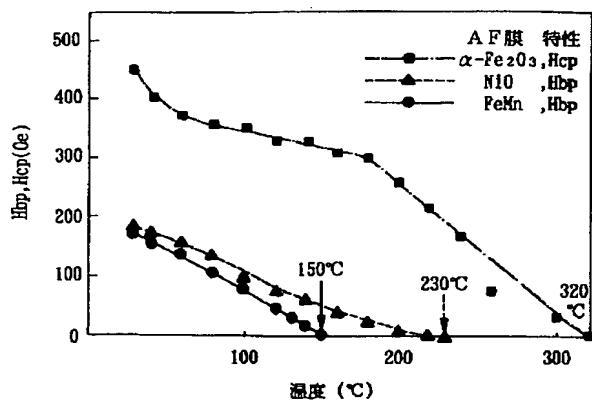
[Drawing 7]



[Drawing 10]

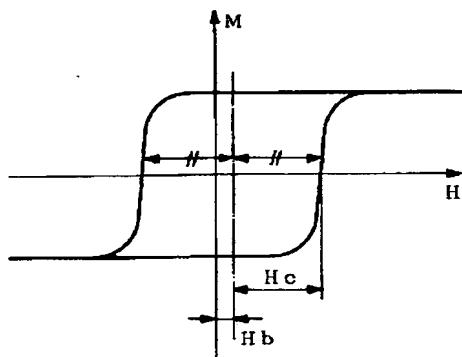


[Drawing 8]

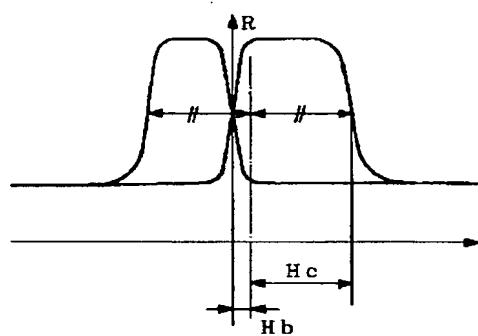


[Drawing 9]

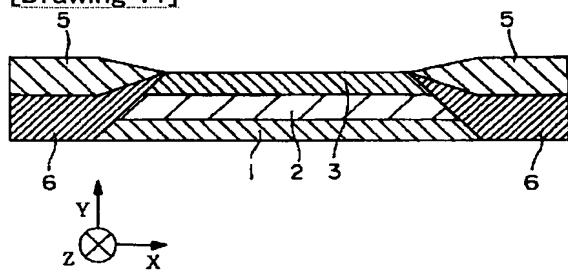
(A)



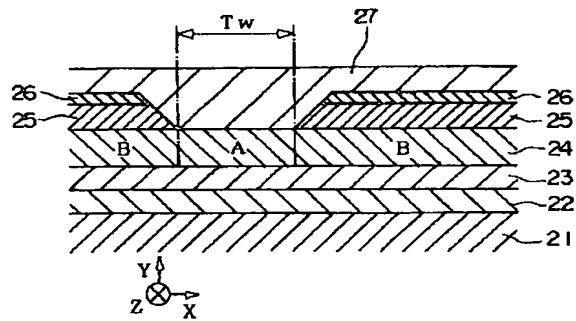
(B)



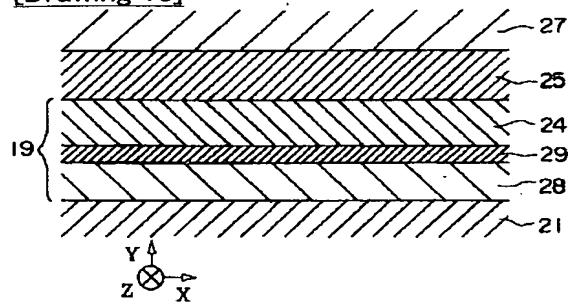
[Drawing 11]



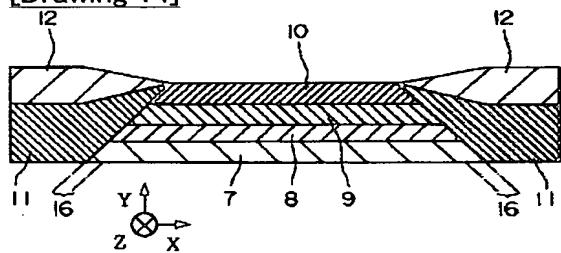
[Drawing 12]



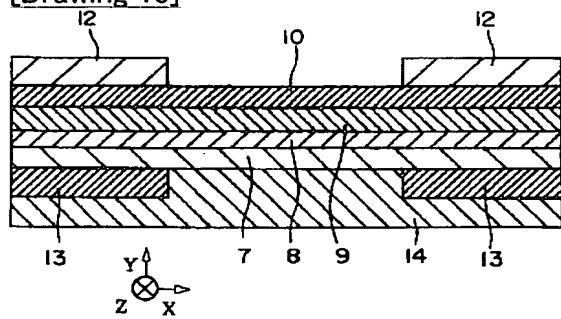
[Drawing 13]



[Drawing 14]



[Drawing 15]



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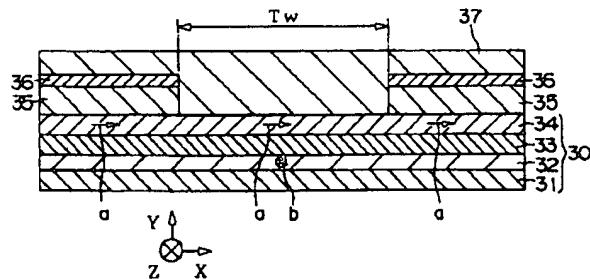
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(54)【発明の名稱】 磁気抵抗効果型センサおよびその製造方法とそのセンサを備えた磁気ヘッド

(57)【要約】

【課題】 本発明は、耐食性に優れ、薄膜において必要十分な交換異方性磁界を印加することができるとともに、線形応答性に優れ、バルクハウゼンノイズを抑制した磁気抵抗効果型センサを提供することを目的とする。

【解決手段】 本発明は、少なくとも2層の強磁性層32、34が、非磁性層33を介して設けられ、前記強磁性層のうち、一方が、その強磁性層と隣接して設けられた反強磁性体の保磁力増大層31により保磁力が大きくなりて磁化反転がピン止めされ、他方の強磁性層の磁化反転が自由にされてなる磁気抵抗効果型センサであり、前記磁化反転が自由にされてなる強磁性層34に対し、この強磁性層34に縦バイアスを印加して一方向性の交換バイアス磁界により磁気異方性を誘起させて磁区を安定化する反強磁性層35が隣接配置されてなる。



【特許請求の範囲】

【請求項 1】 少なくとも 2 層の強磁性層が、非磁性層を介して設けられ、前記強磁性層のうち、一方がその強磁性層と隣接して設けられた第 1 の反強磁性体よりなる保磁力増大層により保磁力が大きくされて磁化反転がピン止めされ、他方の強磁性層の磁化反転が自由にされてなる磁気抵抗効果型センサであり、

前記磁化反転が自由にされてなる強磁性層に対し、この強磁性層に縦バイアスを印加して一方向性の交換バイアス磁界により磁気異方性を誘起させて磁区を安定化する第 2 の反強磁性体よりなる反強磁性層が隣接配置されてなることを特徴とする磁気抵抗効果型センサ。

【請求項 2】 前記磁化反転がピン止めされた強磁性層の磁化と、磁化が自由にされた強磁性層の磁化が、外部磁界のない状態で互いに略直交されてなることを特徴とする請求項 1 に記載の磁気抵抗効果型センサ。

【請求項 3】 前記保磁力増大層が α -Fe₂O₃ からなり、この保磁力増大層に磁化反転をピン止めされた強磁性層の保磁力が、前記保磁力増大層により強磁性層に誘起される一方向性の交換バイアス磁界よりも大きくされてなることを特徴とする請求項 1 または 2 記載の磁気抵抗効果型センサ。

【請求項 4】 前記縦バイアス印加のための第 2 の反強磁性層が、前記磁化反転を自由にされてなる強磁性層の感磁部分の両端側に感磁部分の幅に相当する所定のトラック幅をあけて強磁性層に接して対向配置されてなることを特徴とする請求項 1 ~ 3 のいずれかに記載の磁気抵抗効果型センサ。

【請求項 5】 前記磁化反転を自由にされた強磁性層が、トラック幅に相当する感磁部分の幅の分のみ形成され、その強磁性層の両側に形成された反強磁性層とこの反強磁性層に積層された他の強磁性層との積層体により、前記磁化反転を自由にされた強磁性層に縦バイアスが印加されてなることを特徴とする請求項 1 ~ 3 のいずれかに記載の磁気抵抗効果型センサ。

【請求項 6】 前記縦バイアス印加のための第 2 の反強磁性層に積層された強磁性層が非晶質薄膜からなることを特徴とする請求項 5 記載の磁気抵抗効果型センサ。

【請求項 7】 前記縦バイアスを印加するための反強磁性層が、X-Mn (ただし X は、Fe, Co, Ni, Cr, Pt, Pd, Ir, Ru, Rh のうちの 1 種または 2 種以上を示す。) 系合金薄膜からなることを特徴とする請求項 1 ~ 6 のいずれかに記載の磁気抵抗効果型センサ。

【請求項 8】 請求項 1 ~ 7 のいずれかに記載の磁気抵抗効果型センサが備えられてなることを特徴とする磁気ヘッド。

【請求項 9】 請求項 4 記載の磁気抵抗効果型センサの製造方法において、前記縦バイアス印加のための第 2 の反強磁性層と隣接する磁化反転が自由にされる強磁性層

磁界を印加しながら形成するか、あるいは、強磁性層形成後に磁界中で熱処理を行うことにより生じさせ、保磁力増大層に隣接する磁化反転がピン止めされる強磁性層の磁化方向を、前記磁化反転が自由にされる強磁性層の磁気異方性の方向を決定する工程の後に行う着磁工程により決定することを特徴とする磁気抵抗効果型センサの製造方法。

【請求項 10】 請求項 5 記載の磁気抵抗効果型センサの製造方法において、前記縦バイアス印加のための第 2 の反強磁性層と隣接して積層体を構成する強磁性層に誘起される一方向性の磁気異方性を、その強磁性層を磁界を印加しながら形成するか、あるいは、強磁性層形成後に磁界中で熱処理を行うことにより生じさせ、保磁力増大層に隣接する磁化反転がピン止めされる強磁性層の磁化方向を、前記積層体の強磁性層の磁気異方性の方向を決定する工程の後に行う着磁工程により決定することを特徴とする磁気抵抗効果型センサの製造方法。

【発明の詳細な説明】

【0001】

【発明の属する技術分野】 本発明は、磁気ヘッド、位置センサ、回転センサ等に適用される磁気抵抗効果素子を利用したセンサとその製造方法およびそのセンサを備えた磁気ヘッドに関する。

【0002】

【従来の技術】 従来、磁気抵抗効果型読み取りヘッド (MR ヘッド) として、異方性磁気抵抗効果現象を用いた AMR (Anisotropic Magnetoresistance) ヘッドと、伝導電子のスピンドル散乱現象を用いた GMR (Giant Magnetoresistance : 巨大磁気抵抗効果) ヘッドとが知られており、GMR ヘッドの 1 つの具体例として、低外部磁界で高磁気抵抗効果を示すスピンドル (Spin-Valve) ヘッドが米国特許第 5 159513 号明細書に示されている。図 10 と図 11 は AMR ヘッド素子構造の概略構成を示す図である。図 10 に示すヘッド素子にあっては、軟磁性層 1 上に電気絶縁層 2 と強磁性層 (AMR 材料層) 3 とが積層され、強磁性層 3 の両端部上にトラック幅に相当する間隔をあけて反強磁性層 4、4 が積層され、更にそれらの上に導電層 5 が積層されて構成されている。図 11 に示すヘッド素子にあっては、軟磁性層 1 と電気絶縁層 2 と強磁性層 3 を積層して積層体が構成され、この積層体の両側に積層体を挟むように磁石層 6、6 が設けられ、磁石層 6 の上に導電層 5 が設けられて構成されている。

【0003】 この種の AMR ヘッドの最適動作のためには、AMR 効果を示す強磁性層 3 に対して 2 つのバイアス磁界が必要とされている。第 1 のバイアス磁界は、強磁性層 3 の抵抗変化を磁気媒体からの磁束に対して線形応答させるためのものであり、この第 1 のバイアス磁界は、磁気媒体の面に対して垂直方向 (図 1 の Z 方向) で

この第1のバイアス磁界は、横バイアスと呼ばれ、検出電流を導電層5からAMRヘッド素子に流すことにより得ることができる。第2のバイアス磁界は、通常、縦バイアスと呼ばれ、磁気媒体と強磁性層3の膜面に対して平行(図1のX方向)に印加される。この縦バイアス磁界の目的は強磁性層3が多数の磁区を形成することによって生じるバルクハウゼンノイズを抑制すること、即ち、磁気媒体からこの磁束に対してノイズの少ないスマーズな抵抗変化にするためである。

【0004】ところで、前記のバルクハウゼンノイズを抑制するためには、強磁性層3を単磁区化することが必要であり、そのための縦バイアスの印加方法には、通常、2通りの方法が知られている。第1の方法は、図1-1に示すヘッド素子構造を採用し、強磁性層3の両側に磁石層6、6を配置して磁石層6からの漏れ磁束を利用する方法であり、第2の方法は、図1-0に示すヘッド素子構造を採用し、反強磁性層4と強磁性層3の接触界面で生じる交換異方性磁界を利用する方法である。

【0005】そして、前記反強磁性層による交換異方性結合を利用した素子構造として、図1-2に示すエクスチエンジバイアス方式のものと、図1-3に示すスピンドル方式のものが知られている。図1-2は図1-0に示す構造に類するもので、下部絶縁層2-1上に強磁性層2-2と非磁性層2-3と磁気抵抗効果を奏する強磁性層2-4とを積層し、トラック幅T_Wに相当する間隔をあけて反強磁性層2-5、2-5とリード層2-6、2-6を設け、それらの上に上部絶縁層2-7を設けた構造である。図1-2に示す構造においては、強磁性層2-4と反強磁性層2-5の両層の境界面での交換異方性結合により、強磁性層2-4に縦バイアスが与えられて図1-2のB領域(強磁性層2-4と強磁性層2-5が接触した領域)はX方向へ単磁区化され、これに誘発されてトラック幅内のA領域にて強磁性層2-4がX方向へ単磁区化される。定常電流はリード層2-6から反強磁性層2-5を経て強磁性層2-4に与えられる。強磁性層2-4に定常電流が与えられると、強磁性層2-2からの静磁結合エネルギーにより強磁性層2-4中にZ方向への横バイアス磁界が与えられる。このように縦バイアス磁界と横バイアス磁界により磁化された強磁性層2-4に磁気媒体からの漏れ磁界が与えられると、この漏れ磁界の大きさに比例して定常電流に対する電気抵抗が線形応答して変化するので、この電気抵抗の変化により漏れ磁界を検出できる。

【0006】図1-3に示す構造は、下部絶縁層2-1上に、磁気抵抗効果素子1-9を構成するフリー強磁性層2-8と非磁性導電層2-9と強磁性層2-4を積層し、更に、強磁性層2-4の上に反強磁性層2-5と上部絶縁層2-7を順次積層して構成されている。図1-3に示す構造において定常電流は、磁気抵抗効果素子1-9に与えられる。反強磁性層2-5との交換異方性結合により、強磁性層2-4の磁化がZ方向へ固定され、Y方向へ移動する磁気媒体

からの漏れ磁界が与えられると、フリー強磁性層2-8の磁化方向の変化により磁気抵抗効果素子1-9の電気抵抗が変化するので、この電気抵抗の変化により磁気媒体の漏れ磁界を検出できる。

【0007】一方、前記スピンドル構造を採用し、前述の構造を最適動作させるための構成として、図1-4に示すようにフリー強磁性層7と非磁性中間層8とピン止め強磁性層9と反強磁性層10を積層し、この積層体の両側に磁石層1-1、1-1を設け、その上に導電層1-2を設けた構造、あるいは、図1-5に示すように、フリー強磁性層7と非磁性中間層8とピン止め強磁性層9と反強磁性層10を積層し、積層体の両側を上下から導電層1-2と反強磁性層1-3で挟む込み、それら全体をバッファ層1-4に隣接させた構造が知られている。

【0008】図1-4に示す構造であると、フリー強磁性層7には磁石層1-1、1-1でトラック方向(図1-4のX方向)のバイアスを印加し単磁区化した状態でトラック方向に磁化を向けさせるとともに、ピン止め強磁性層9の磁化方向を図1-4中のZ方向、即ち、フリー強磁性層7の磁化方向と直交する方向にバイアスを印加して単磁区化した状態で図中Z方向に向けさせておく必要がある。即ち、磁気媒体からの磁束(図1-4のZ方向)により、前記ピン止め強磁性層9の磁化方向は変化してはならず、フリー強磁性層7の方向がピン止め強磁性層9の磁化方向に対して $90 \pm \theta$ °の範囲で変化することにより磁気抵抗効果の線形応答性が得られる。

【0009】前記ピン止め強磁性層9の磁化方向を図1-4と図1-5のZ方向に固定させるためには、比較的大きなバイアス磁界が必要であり、このバイアス磁界は大きければ大きいほど良いことになる。図1-4と図1-5のZ方向の反磁界に打ち勝ち、磁気媒体からの磁束により磁化方向が揺れないためには、少なくとも100 Oeのバイアス磁界が必要である。このバイアス磁界を得るための方法として図1-4と図1-5に示す構造にあっては、ピン止め強磁性層9に反強磁性層10を接触させて設けることにより生じる交換異方性磁界を利用している。

【0010】また、フリー強磁性層7に印加するバイアスは、線形応答性を確保するための目的と、多数の磁区を形成することから生じるバルクハウゼンノイズを抑制するためのものであり、AMRヘッドにおける縦バイアスと同様の方法、即ち、図1-4に示す構造においては、フリー強磁性層7の両側に磁石層1-1を設け、磁石層1-1からの漏れ磁束をバイアスとして利用する方法を採用している。また、図1-5に示す構造においては、フリー強磁性層7の両端部側に反強磁性層1-3を設け、フリー強磁性層7と反強磁性層1-3との接触界面で生じる交換異方性磁界をバイアスとして利用する方法を採用している。

【0011】以上のように、AMRヘッドの際の縦バイアス、スピンドルヘッドの際のピン止め強磁性層のバ

イアス、フリー強磁性層のバイアスに反強磁性層との接触界面で生じる交換異方性磁界を利用することにより、線形応答性が良く、バルクハウゼンノイズを抑制した磁気抵抗効果型ヘッドが実現される。

【0012】

【発明が解決しようとする課題】ところで、前記交換異方性磁界は、強磁性層と反強磁性層の接触界面における双方の磁気モーメント間の交換相互作用に起因する現象であり、強磁性層、例えば、NiFe層との交換異方性磁界を生じる反強磁性層としては、FeMn層が良く知られている。しかしながら、FeMn層は、耐食性が著しく悪く、磁気ヘッドの製造工程および磁気ヘッド作動中に腐食が進行し、交換異方性磁界が大きく劣化してしまう問題と、場合によっては磁気媒体を破損させてしまう問題がある。また、磁気ヘッド作動中のFeMn層近傍の温度は、定常検出電流による発熱で120°C程度まで容易に上昇することが知られているが、FeMn層による交換異方性磁界は温度変化に対して極めて敏感であり、約150°Cの温度で消失（ブロッキング温度：T_b）するまで、温度に対してほぼ直線的に交換異方性磁界が減少してしまうために、安定した交換異方性磁界が得られない問題がある。

【0013】一方、FeMn膜の耐食性とブロッキング温度を改善した発明として例えば、特開平6-76247号公報に示されている面心正方晶構造を有するNiMn合金またはNiMnCr合金があるが、NiMn層の耐食性はFeMn層の耐食性よりは良いものの、実用上不十分である。また、NiMnCr層は、NiMn層の耐食性を向上させるためにCrを添加した合金層であるが、Cr添加により耐食性は向上するものの、交換異方性磁界の大きさとブロッキング温度が低下してしまう問題がある。

【0014】また、NiMn合金またはNiMnCr合金において交換異方性磁界を得るために、反強磁性層の一部に面心正方晶(fct)構造を有するCuAg-Iタイプの規則構造結晶を形成しなければならず、規則-不規則変態の制御や規則相、不規則相の体積比率の制御が当然必要となるために、安定した特性を得るには、磁気ヘッドの製造工程における工程制御と管理が極めて複雑にならざるを得ない問題がある。また、必要とされる交換異方性磁界を得るために、磁界中熱処理を複数回繰り返さなくてはならないことと、降温速度を緩やか、例えば255°Cから45°Cまで降温するために17時間（Appl. Phys. Lett. 65(9), 29 August 1994参照）を要する問題があり、製造工程における処理時間が長くなつて製造効率が悪くなる問題があった。

【0015】また、FeMn層のブロッキング温度を改善する発明として、NiFe/FeMn積層膜を260~350°Cの温度で20~50時間熱処理し、熱処理に

元合金層を形成する方法が、米国特許第4809109号明細書に示されているが、この方法ではFeMn層の最大の問題点である耐食性の向上には効果がないことが理解できるとともに、必要な熱処理時間が20~50時間と極めて長いことから、製造効率を低下させる問題がある。一方、既存出版物、例えば、朝倉書店発行の「磁性体ハンドブック」には、反強磁性材料として、Mn系合金、例えば、NiMn、PtMn、AuMn、RhMn等の材料が示されているが、強磁性層と接触界面における交換異方性磁界に関するコメントは皆無であり、更に膜厚が数100Åといった極薄膜における反強磁性層自身の特性や交換異方性磁界に関しては全く不明である。

【0016】更に、図14に示す素子構造において、左右の磁石層11、11によってバイアスが印加されたフリー強磁性層7にあっては、磁石層11、11に近接するトラックエンド部（図14に符号16で示す領域）の磁化の向きが容易に変化しない不感領域となりやすく、磁気媒体の記録密度の向上に伴う更なる狭トラック化が進められた場合に問題を生じるおそれがあった。このため、図15に示す交換結合バイアスを用いた素子構造が有望となり得るが、スピンドル構造の素子構造に交換結合バイアス方式により縦バイアスを印加しようとする場合、以下の問題があった。

【0017】図15に示すスピンドル構造において、ピン止め強磁性層9の磁化の回転を固定するのは、反強磁性層10であり、一方、縦バイアスのためにフリー強磁性層7のトラックエンド部の磁化の向きを固定するのは、反強磁性層13、13であり、反強磁性層10と反強磁性層13がそれぞれ固定するべき磁化の向きは90°異なる。ここで、各磁性膜の磁化の方向を制御するには、通常、磁界中成膜処理や成膜後の磁場中アニール処理により行っているが、最初に成膜した反強磁性層13の磁化の方向を乱すことなく後で成膜する反強磁性層10の磁化方向を制御することは、極めて難しい問題がある。また、特開平8-45032号明細書に記載の如く、ネール温度の異なる磁性膜を使い分けて磁性膜毎に熱処理温度を変えることにより前記問題を解決する技術が開示されているが、この技術によってもネール温度の低いFe-Mn合金を使用する必要があるので、前述の耐食性の面での欠点とブロッキング温度に起因する温度変化に敏感な欠点は解消できない問題がある。

【0018】本発明は前記事情に鑑みてなされたもので、耐食性に優れ、薄膜において必要十分な交換異方性磁界を印加することができるとともに、線形応答性に優れ、バルクハウゼンノイズを抑制した磁気抵抗効果型センサを提供することを目的とする。また、本発明は、ブロッキング温度が高い反強磁性層を提供することにより、線形応答性に優れた上で温度変化に強く、バルクハ

ることを目的とする。更に本発明は、前述の優れた特性を有する磁気抵抗効果型センサを製造するにあたり、特別な熱処理装置を用いて磁場中熱処理を長時間行う必要が無く、通常の熱処理で製造できるとともに、熱処理時間も従来よりも短縮できる製造方法を提供することを目的とする。

【0019】

【課題を解決するための手段】本発明は前記課題を解決するために、少なくとも2層の強磁性層が、非磁性層を介して生成され、前記強磁性層のうち、一方が、その強磁性層と隣接して設けられた第1の反強磁性体よりも保磁力増大層により保磁力が大きくされて磁化反転がピン止めされ、他方の強磁性層の磁化反転が自由にされてなる磁気抵抗効果型センサであり、前記磁化反転が自由にされてなる強磁性層に対し、この強磁性層に縦バイアスを印加して一方向性の磁気異方性を誘起させて磁区を安定化する反強磁性体からなる第2の反強磁性層が隣接配置されてなる。次に本発明においては、前記磁化反転がピン止めされた強磁性層の磁化と、磁化が自由にされた強磁性層の磁化が、外部磁界のない状態で互いに略直交されてなることが好ましい。更に本発明において、前記保磁力増大層が α -Fe₂O₃からなり、この保磁力増大層に磁化反転をピン止めされた強磁性層の保磁力が、 α -Fe₂O₃により強磁性層に同時に誘起される一方向の交換バイアス磁界よりも大きくされてなることが好ましい。

【0020】本発明において、前記縦バイアス印加のための第2の反強磁性層が、前記の磁化反転が自由にされてなる強磁性層の感磁部分の両端側に感磁部分の幅に相当する所定のトラック幅をあけて強磁性層に接して対向配置されてなることも好ましい。本発明において、前記磁化反転を自由にされた強磁性層が、トラック幅に相当する感磁部分の幅の分のみ形成され、その強磁性層の両側に形成された反強磁性層とこの反強磁性層に積層された他の強磁性層との積層体により、前記磁化反転を自由にされた強磁性層に縦バイアスが印加されてなることが好ましい。更に、前記縦バイアス印加のための第2の反強磁性層に積層される強磁性層が非晶質薄膜からなることが好ましい。また、前記縦バイアスを印加するための反強磁性層が、X-Mn（ただしXは、Fe、Co、Ni、Cr、Pt、Pd、Ir、Ru、Rhのうちの1種または2種以上を示す。）系合金薄膜からなることが好ましい。そして本発明は、前記いずれかに記載の構成の磁気抵抗効果型センサが備えられてなる磁気ヘッドを提供する。

【0021】一方、前記縦バイアス印加のための第2の反強磁性層が、前記の磁化反転が自由にされてなる強磁性層の感磁部分の両端側に感磁部分の幅に相当する所定のトラック幅をあけて強磁性層に接して対向配置されてなる構成の前記磁気抵抗効果型センサを製造する場合に、前記縦バイアス印加のための第2の反強磁性層と隣

接する磁化反転が自由にされる強磁性層に誘起される一方向性の磁気異方性を、その強磁性層を磁界を印加しながら形成するか、あるいは、強磁性層形成後に磁界中で熱処理を行うことにより生じさせ、保磁力増大層に隣接する磁化反転がピン止めされる強磁性層の磁化方向を、前記磁化反転が自由にされる強磁性層の磁気異方性の方向を決定する工程の後に行う着磁工程により決定することが好ましい。

【0022】また、前記磁化反転を自由にされた強磁性層が、トラック幅に相当する感磁部分の幅の分のみ形成され、その強磁性層の両側に形成された反強磁性体の反強磁性層と他の強磁性層との積層体により縦バイアスが印加されてなる構成の前記磁気抵抗効果型センサを製造する場合に、反強磁性層と隣接して積層体を構成する強磁性層に誘起される一方向性の磁気異方性を、その強磁性層を磁界を印加しながら形成するか、あるいは、強磁性層形成後に磁界中で熱処理を行うことにより生じさせ、保磁力増大層に隣接する磁化反転がピン止めされる強磁性層の磁化方向を、前記積層体の強磁性層の磁気異方性の方向を決定する工程の後に行う着磁工程により決定することが好ましい。

【0023】

【発明の実施の形態】以下図面を参照して本発明の一形態について説明する。図1は本発明に係る磁気抵抗効果型センサの一形態を示すものであり、保磁力増大層31上に、強磁性層32と非磁性層33と強磁性層34が順次積層され、強磁性層34の両端部上に、トラック幅T_Wに相当する間隔を相互の間にあけて反強磁性層35、35が積層され、反強磁性層35上にリード層36が積層されるとともに、リード層36と強磁性層34を覆つて上部絶縁層37が積層されている。なお、この形態の構造においては、保磁力増大層31と強磁性層32と非磁性層33と強磁性層34とによりスピンドル型の磁気抵抗効果素子30が構成される。

【0024】前記保磁力増大層31は、その上に形成される強磁性層32に磁気の交換結合力を作用させて強磁性層32の保磁力を増大させ、磁化の向きをピン止めするためのものであり、この保磁力増大層31は、反強磁性体、特に酸化物反強磁性体から構成されることが好ましく、1つの具体例としては、 α -Fe₂O₃から形成される。前記強磁性層32、34は、いずれも強磁性体の薄膜からなるが、具体的にはNi-Fe合金、Co-Fe合金、Ni-Co合金、Co、Ni-Fe-Co合金などからなる。また、強磁性層32をCo層から、強磁性層34をNi-Fe合金層から、あるいはCo層とNi-Fe合金層の積層構造から構成することもできる。なお、Co層とNi-Fe合金層との2層構造とする場合は、非磁性層33側に薄いCo層を配置する構造とすることもできる。

【0025】これは、非磁性層33を強磁性層32、3

4で挟む構造の巨大磁気抵抗効果発生機構にあっては、CoとCuの界面で伝導電子のスピン依存散乱の効果が大きいこと、および、強磁性層32、34を同種の材料から構成する方が、異種の材料から構成するよりも、伝導電子のスピン依存散乱以外の因子が生じる可能性が低く、より高い磁気抵抗効果を得られることに起因している。このようなことから、強磁性層32をCoから構成した場合は、強磁性層34の非磁性層33側を所定の厚さでCo層に置換した構造が好ましい。また、Co層を特に区別して設けなくとも、強磁性層34の非磁性層33側にCoの多く含ませた合金状態とし、上部保護層37側に向かうにつれて徐々にCo濃度が薄くなるような濃度勾配層としても良い。

【0026】前記非磁性層33は、Cu、Cr、Au、Agなどに代表される非磁性体からなり、20～40Åの厚さに形成されている。ここで非磁性膜33の厚さが20Åより薄いと、強磁性層32と強磁性層34との間で磁気的結合が起こりやすくなる。また、非磁性層33が40Åより厚いと磁気抵抗効果を生じる要因である非磁性層33と強磁性層32、34の界面で散乱される伝導電子の率が低下し、電流の分流効果により磁気抵抗効果が低減されてしまうので好ましくない。

【0027】前記反強磁性層35は、反強磁性層31とは異なる反強磁性体、例えば、不規則構造を有するX-Mn合金からなることが好ましい。ここで前記組成式においてXは、Ru、Rh、Ir、Pd、Ptのいずれか1種または2種以上からなることが好ましい。前記のMn系合金は、不規則結晶構造を有するものであるが、この不規則結晶構造とは、面心正方晶(fcc規則格子；CuAuI構造など)のような規則的な結晶構造ではない状態を意味している。即ち、本発明でのMn合金は、スパッタリングなどにより成膜された後に、前記面心正方晶などの規則的な結晶構造(CuAuI構造など)とするための高温かつ長時間の加熱処理を行わないものであり、不規則結晶構造とは、スパッタリングなどの成膜法により形成されたままの状態、あるいはこれに通常のアニール処理が施された状態のものである。

【0028】前記X-Mn合金のXが单一の金属原子である場合のXの含有率の好ましい範囲は、Ruは10～45原子%、Rhは10～40原子%、Irは10～40原子%、Pdは10～25原子%、Ptは10～25原子%である。なお、以上の記載において10～45原子%とは、10原子%以上で45原子%以下を意味し、「～」で表示する数値範囲の上限下限は全て「以上」および「以下」で規定されるものとする。

【0029】前記不規則結晶構造のX-Mn系合金の反強磁性層35であるならば強磁性層34に一方向異方性により縦バイアスを印加することができ、強磁性層35に接する強磁性層34の両端部の磁化の回転をピン止め

磁性層35であるならば、従来の反強磁性層のFe-Mnに比べて耐食性に優れ、また温度変化に対する交換異方性磁界(H_{ex})の変動が少なくなる。よって反強磁性層35を用いることで耐環境性に強く、磁気媒体からの漏れ磁界の検出時にノイズが発生しにくく、高品位な磁気検出が可能なものとなる。また、X-Mn合金の反強磁性層35であるならば、高温かつ長時間の加熱処理が不要なために、加熱に伴う各磁性層間の元素拡散も生じる可能性が低く、磁気特性の変化や劣化あるいは絶縁層の破壊といった問題は生じない。

【0030】前記上部保護層37は上部シールド磁性層との間隔(Gap)を設定するためと、強磁性層34の酸化防止などのために設ける層である。また、この上部保護層37はAl₂O₃、石英などの絶縁材料から構成することが好ましい。

【0031】また、前記強磁性層34上に反強磁性層35を設けることにより、強磁性層34に一方向異方性を付与して図1の矢印aに示す方向に磁化の向きを揃えてバイアスを印加し、単磁区化することができる。また、強磁性層32の全面に密着させた保磁力増大層31により、強磁性層32の磁化の向きをピン止めして図1の紙面に垂直なb方向に磁化の向きを揃えることができる。以上のことから、強磁性層34の磁化の向きを図1と図2の矢印a方向に向け、強磁性層32の向きを矢印b方向に向けすることで両者をほぼ90°で直交させて揃えることができる。

【0032】図1に示す構造において定常電流は、磁気抵抗効果素子30に与えられる。図1に示す構造であるならば、保磁力増大層31の存在により強磁性層32が磁気的交換結合を受けて保磁力が増大されてその磁化の向きがピン止めされ、他の強磁性層34の磁化の方向がトラック幅T_Wに相当する領域において自由にされる結果、強磁性層32と34の間に保磁力差が生じ、これに起因して巨大磁気抵抗効果が得られる。即ち、磁化の回転が自由にされた強磁性層34の中央部のトラック幅T_Wに相当する部分に、Y方向へ移動する磁気記録媒体からの漏れ磁界などのような外部磁界が作用すると、強磁性層34の磁化の向きが容易に回転するので、回転に伴って磁気抵抗効果素子30に抵抗変化が生じ、この抵抗変化を測定することで磁気記録媒体の磁気情報を読み取ることができる。また、この抵抗変化の際に強磁性層34は単磁区化されていて、しかも縦バイアスが印加されているので、バルクハウゼンノイズを生じることなく、良好な線形応答性で抵抗変化が得られる。

【0033】また、図1に示す構造においては、保磁力増大層31をα-Fe₂O₃から構成したが、α-Fe₂O₃は元々酸化物でありFeMnに比べて耐食性に優れ、しかもネール温度が高いため、温度変動に強い特徴がある。なお、図1に示す素子構造にあっては保磁力増大層

の構成材料は強磁性層32に磁気的交換結合力を作用させて保磁力を高くするようなものであれば良いので、他の反強磁性体、酸化物反強磁性体あるいは高保磁力磁性体から構成しても良いのは勿論である。

【0034】次に図3は、本発明に係る磁気抵抗効果センサの他の形態を示すもので、この形態の磁気抵抗効果センサは、保磁力増大層41とピン止め強磁性層42と非磁性層43とフリー強磁性層44を積層して断面台形状の積層体45を形成し、この積層体45の両側に反強磁性層46、46を設け、各反強磁性層46上に強磁性層47と導電層48を積層して構成されている。この形態において反強磁性層46は、その端部46aにおいて反強磁性層41とピン止め強磁性層42と非磁性層43の側部を覆い、フリー強磁性層44の側部を厚み半分程度覆って設けられ、反強磁性層46上の強磁性層47はその端部でフリー強磁性層44の側部を厚み半分程度覆って設けられているが、各層の厚さ関係は図面に示したものに限らない。また、反強磁性層46と強磁性層の上下の位置関係を逆にしたもの、あるいは、反強磁性層46と強磁性層47の積層体を多段重ね構造にしたものでも良い。前記の構造において、保磁力増大層41は先の例で用いた保磁力増大層31と同等の材料からなり、ピン止め強磁性層42は先の例で用いた強磁性層32と同等の材料からなり、非磁性中間層43は先の例で用いた非磁性層33と同等の材料からなり、フリー強磁性層44は先の例で用いた強磁性層34と同等の材料からなる。また、反強磁性層46は先の例で用いた反強磁性層35と同等の材料からなり、強磁性層47は非晶質のCoNbZr、CoFeB、CoFeZrなどの強磁性層およびそれらとNiFe合金などの結晶質膜との積層膜からなることが好ましい。

【0035】図3に示す構造においては、反強磁性層46の一方向異方性により強磁性層47の磁化の向きを図3の矢印a方向にピン止めするとともに、強磁性層47の磁化の向きに合わせてフリー強磁性層44の磁化の向きを矢印a方向に誘導して縦バイアスを印加することができる。また、保磁力増大層41によりピン止め強磁性層42の磁化の向きを図3の矢印b方向にピン止めする。以上のように、フリー強磁性層44と強磁性層47を単磁区化するとともにフリー強磁性層44の磁化の向きをピン止め強磁性層42の磁化の向きに対して直交させることができる。次に、強磁性層47を非晶質の強磁性体から構成すると、非晶質の強磁性層はMR効果が小さいので、サイドリーディング(トラック部以外で磁気媒体の磁界を拾うこと)が少なく、かつ、一方向異方性も分散の少ないものを導入できる利点がある。

【0036】この形態の構造においては、先の形態の構造と同様に、フリー強磁性層44を単磁区化できるとともに、縦バイアスを印加しているので、バルクハウゼンノイズを生じることなく、良好な線形応答性で抵抗変化

が得られる。

【0037】次に図4～図6は、図1または図3に示す素子構造を備えた薄膜磁気ヘッドの一構造例を示す。この例の磁気ヘッドHAは、ハードディスク装置等に搭載される浮上式のもので、この磁気ヘッドHAのスライダ51は、図4の(イ)で示す側がディスク面の移動方向の上流側に向クリーディング側で、図4の(ロ)で示す側がトレーリング側である。このスライダ51のディスクに對向する面では、レール状のABS面51a、51a、51bと、エアーグループ51cが形成されている。そして、このスライダ51のトレーリング側の端面51dに薄膜磁気ヘッド50が設けられている。

【0038】この例で示す薄膜磁気ヘッド50は、図5と図6に断面構造を示すような複合型磁気ヘッドであり、スライダ51のトレーリング側端面51d上に、MRヘッド(読み出ヘッド)h₁と、インダクティブヘッド(書き込ヘッド)h₂とが順に積層されて構成されている。

【0039】この例のMRヘッドh₁は磁気抵抗効果を利用してディスクなどの記録媒体からの漏れ磁束を検出し、磁気信号を読み取るものである。図5に示すようにMRヘッドh₁は、スライダ51のトレーリング側端部に形成されたセンダスト(Fe-Al-Si)等の磁性合金からなる下部ギャップ層53上に、アルミナ(Al₂O₃)などの非磁性材料により形成された上部ギャップ層54が設けられている。そして、この上部ギャップ層54上に、巨大磁気抵抗効果素子となる図1または図3に示す構造の磁気抵抗効果型センサが積層されている。更にその上には、アルミナなどからなる上部ギャップ層が形成され、その上に上部シールド層が形成されており、この上部シールド層は、その上に設けられるインダクティブヘッドh₂の下部コア層55と兼用にされている。

【0040】インダクティブヘッドh₂は、下部コア層55の上に、ギャップ層64が形成され、その上に平面的に螺旋状となるようにパターン化されたコイル層66が形成され、コイル層66は絶縁材料層67に囲まれている。絶縁材料層67の上に形成された上部コア層68は、その先端部68aをABS面51bにて下部コア層55に微小間隙をあけて対向し、その基端部68bを下部コア層55と磁気的に接続させて設けられている。また、上部コア層68の上にはアルミナなどからなる保護層69が設けられている。

【0041】インダクティブヘッドh₂では、コイル層66に記録電流が与えられ、コイル層66からコア層に記録電流が与えられる。そして、磁気ギャップGの部分での下部コア層55と上部コア層68の先端部からの漏れ磁界によりハードディスクなどの記録媒体に磁気信号を記録することができる。また、MRヘッドh₁においては、ハードディスクなどの記録媒体からの微小の漏れ

磁界の有無により強磁性層4 4の抵抗が変化するので、この抵抗変化を読み取ることで記録媒体の記録内容を読み取ることができる。更に、この構成の磁気ヘッドHAにおいては、先に説明した構造の磁気抵抗効果型センサが設けられているので、バルクハウゼンノイズが無く、線形応答性に優れた抵抗変化を得ることができ、更に従来の磁気ヘッドよりも高いMR比を得ることができるので、読み出性能が優れる特徴がある。

【0042】次に、図に示す構造の磁気抵抗効果型センサを得るには、Al₂O₃-TiC（アルチック）などの基板を高周波マグネットロンスパッタ装置あるいはイオンビームスパッタ装置のチャンバ内に設置し、チャンバ内をArガスなどの不活性ガス雰囲気としてから順次必要な層を成膜することにより作成することができる。成膜に必要なターゲットはα-Fe₂O₃ターゲット、Ni-Fe合金ターゲット、Cuターゲットなどである。次に本発明に係る図3に示す磁気抵抗効果型センサを製造するには、Arガス圧3mTorr以下の雰囲気中において図1、3のZ方向に磁界を印加しながら、スパッタにより基板上にα-Fe₂O₃からなる保磁力増大層4 1を形成し、この保磁力増大層4 1上に、非磁性層4 3を挟んで2層の強磁性層4 2、4 4を形成するとともに、フォトリソグラフィプロセスとイオンミリングによりトラック幅に相当する部分を残して他の部分を除去して積層体4 5とする。次に前記の磁場の印加方向と直角方向に磁場を印加しながらスパッタにより前記積層体4 5の両端部分に反強磁性層4 6と非晶質の強磁性層4 7と電極層4 8を積層形成する。次いで図3の紙面垂直方向に磁界を印加してピン止め強磁性層4 2を着磁する。以上の処理によってピン止め強磁性層4 2の磁化の向きと強磁性層4 4の磁化の向きが90°直交した図3に示す構造の磁気抵抗効果型センサを得ることができる。

【0043】また、図1に示す構造の磁気抵抗効果型センサを製造するには、保磁力増大層3 1と強磁性層3 2と非磁性層3 3と強磁性層3 4を積層した後に反強磁性層と導電層を積層し、フォトリソグラフィプロセスにより強磁性層と導電層の中央部分を除いた状態で形成し、その後に上部保護層3 7を形成する。また、これらの各層の形成時において、保磁力増大層3 1を成膜する際には、図1、3のZ方向に相当する方向に磁界を印加しながら成膜し、反強磁性層3 5を成膜する際には図1、3

のX方向に相当する方向に磁界を印加しながら成膜を行う。次いで最後に図1の紙面垂直方向に磁界を印加してピン止め強磁性層3 2を着磁する。以上の処理によってピン止め強磁性層3 2の磁化の向きと強磁性層3 4の磁化の向きが90°直交した図1に示す構造の磁気抵抗効果型センサを得ることができる。

【0044】

【実施例】高周波マグネットロンスパッタ装置を用い、Al₂O₃膜を被覆したAl₂O₃-TiC（アルチック）基板上に、複数のターゲットを用いて以下に示す構造になるようにスパッタして積層体を作成し図3に示す構造の磁気抵抗効果型センサを製造した。この際、α-Fe₂O₃からなる保磁力増大層の層厚を500Å、Ni₈₀Fe₂₀合金からなる強磁性層層厚を30Å、Cuからなる非磁性層の層厚を20Å、Ni₈₀Fe₂₀合金からなる強磁性層の層厚を75Å、Taからなる保護層の層厚を30Åとした。また、基板には、ピン止め強磁性層が図3の矢印b方向に異方性を有するようにするために、矢印b方向に200Oeの磁界を印加しながら成膜した。

【0045】得られた積層体に対し、フォトリソグラフィープロセスとイオンミリングによりトラック幅（感磁部分の幅）2μmの部分を残して積層体の両端部を除去し、この残った感磁部分の両側に、厚さ300Åの反強磁性層（Pt₅₀Mn₅₀）と厚さ200Åの非晶質層（Co₈₈Nb₈Zr₄）と厚さ700Åの電極層をスパッタにより積層し、この積層の際に前記の印加磁界と90°異なる方向に200Oeの磁界を印加した。最終的に、トラック幅2μm、ハイト（図3の紙面厚さ方向の高さ）1μmとなるようにフォトリソプロセスによりパターニングし、ハイト方向（図3の紙面厚さ方向）に2kOeの磁界を印加してピン止め強磁性層を着磁した。また、一部の試料には、ハイト方向の着磁に先だって、トラック幅方向（図3の左から右方向）に磁場を印加しながら250°Cで5時間の磁界中アニールを施した。

【0046】以上の製造方法で得られた磁気抵抗効果型センサ試料の低磁界での磁気抵抗曲線を測定した結果を表1と図7に示す。なお、印加磁界は前述のハイト方向とした。

【0047】

【表1】

反強磁性層	抵抗変化率 (±50 Oe)	直線性 (±50 Oe)	ヒステリ シス	バルクハウ ゼンノイズ
Pt ₅₀ Mn ₅₀	3.1%	良好	無し	無し
Pd ₅₀ Mn ₅₀	3.6%	良好	無し	無し
Pd ₃₀ Pt ₂₀ Mn ₅₀	3.0%	良好	無し	無し
Ni ₅₀ Mn ₅₀	2.8%	良好	無し	無し
Ru ₅₀ Mn ₅₀	3.4%	良好	無し	無し
Cr ₅₂ Mn ₄₈	2.8%	良好	無し	無し
Fe ₅₁ Mn ₄₉	2.9%	良好	無し	無し
Ir ₁₅ Mn ₈₅	3.1%	良好	無し	無し
Rh ₂₀ Mn ₈₀	3.0%	良好	無し	無し

【0048】図7においてゼロ磁界での抵抗値は、最大と最小の抵抗値のほぼ中点に位置しており、磁化が直交していることを間接的に示している。ほぼ中点に位置していることにより、外部磁界が±50 Oe程度の範囲で変化しても、良好な直線性を有しており、ダイナミックレンジが広いと言える。また、ヒステリシスもバルクハウゼンノイズも見られず、読み出用磁気ヘッドとして好適な特性を示すことが判明した。更に、±50 Oeの範囲での抵抗変化率は3.1%であり、極めて高出力であることも明らかである。また、反強磁性層として、PtMnに代えてPdMn、PdPtMn、NiMn、RuMn、CrMn、FeMn、IrMn、RhMnをそれぞれ用いた試料も製造して同様に測定に供したが、表1に示すように優れた効果を奏することが明らかになった。

【0049】次に図8は、本発明者らが先に、特願平7-78022号明細書において提案している α -Fe₂O₃を用いた磁気抵抗効果型センサ試料のプロッキング温度T_bを示すものである。また、比較のために、特願平7-78022号明細書に記載の比較例構造(NiFe/Cu/NiFe/FeMn(110Å)の積層体とNiFe/Cu/CoPt(80Å)の積層体)のFeMnを用いた構造の試料とFeMnに代えてNiOを用いた試料の温度特性も併記した。ここでH_{bp}は、反強磁性膜に隣接したNiFe膜の磁化反転がシフトするバイアス磁界をいい、H_{cp}は、そのヒステリシスによる保磁力を意味する。図8に示す結果から、 α -Fe₂O₃を用いた磁気抵抗効果型センサ試料は優れた耐熱性も有していることが明らかになった。これは、 α -Fe₂O₃自体のネール温度(677°C)がFeMnやNiOに比べて高いことに起因しているものと思われる。従ってこの α -Fe₂O₃を用いた磁気抵抗効果型センサ試料であるならば、温度変化によつても特性劣化の少ない磁気抵抗効果型センサを提供できる。

【0050】次に、図9(A)は保磁力増大層(α -Fe₂O₃など)に接したピン止め強磁性層の磁化曲線を、図9(B)はそれを用いたスピンドル磁気抵抗効果型

センサの磁気抵抗曲線を示す。図9(A) (B)において、保磁力(H_c)と交換バイアス磁界(H_b)の値がそれぞれ示され、ここでは、H_c>H_bとなる。これに対して図3の反強磁性層46に接する強磁性層では、逆に、H_c<H_bとなる。この場合に、一方向性の異方性が生じていることとなり、本明細書ではこのような関係となる強磁性層について一方向性の異方性が生じていると定義した。

【0051】

【発明の効果】以上説明したように本発明は、感磁部分の磁気抵抗効果素子に隣接させる強磁性層として、非晶質薄膜からなるものを用いると、非晶質の強磁性層はMR効果が小さいので、サイドリーディング(トラック部以外で磁気媒体の磁界を拾うこと)が少なく、かつ、一方向異方性も分散の少ないものを導入できる。

【0052】縦バイアスを印加するための反強磁性層として、X-Mn(ただしXは、Fe, Co, Ni, Cr, Pt, Pd, Ir, Ru, Rhのうちの1種または2種以上を示す。)系合金薄膜からなるものを用いることで、耐食性に優れ、温度変化による交換異方性磁界の変化が小さなものを提供できる。また、X-Mn系合金のある組成範囲であるならば、スパッタリング等の成膜法で成膜したままの状態で特殊な熱処理を行わなくとも使用できるので、従来構造より熱処理条件を緩和できる。

【0053】次に、前記構造の磁気抵抗効果センサを磁気ヘッドに用いるならば、磁気記録媒体からの微小な磁界に線形応答して抵抗変化を起こし、これにより検出感度良くバルクハウゼンノイズの無い磁気情報の読み出を行える磁気ヘッドを提供することができる。

【0054】次に、縦バイアス印加のための反強磁性層と隣接する磁化反転が自由にされる強磁性層に誘起される一方向性の磁気異方性を、その強磁性層を磁界を印加しながら形成するか、あるいは、強磁性層形成後に磁界中で熱処理を行うことにより生じさせ、保磁力増大層に隣接する磁化反転がピン止めされる強磁性層の磁化方向を、前記磁化反転が自由にされる強磁性層の磁気異方性

の方向を決定する工程の後に行う着磁工程により決定することにより、磁化反転がピン止めされた強磁性層の磁化の向きと、磁化反転が自由にされた強磁性層の磁化の向きをほぼ直交させ、しかも縦バイアスを印加した磁気抵抗効果型センサを得ることができる。

【0055】更に、反強磁性層と隣接して積層体を構成する強磁性層に誘起される一方向性の磁気異方性を、その強磁性層を磁界を印加しながら形成するか、あるいは強磁性層形成後に磁界中で熱処理を行うことにより生じさせ、保磁力増大層に隣接する磁化反転がピン止めされた強磁性層の磁化方向を、前記積層体の強磁性層の磁気異方性の方向を決定する工程の後に行う着磁工程により決定することにより、磁化反転がピン止めされた強磁性層の磁化の向きと、磁化反転が自由にされた強磁性層の磁化の向きをほぼ直交させ、しかも、縦バイアスを印加した磁気抵抗効果型センサを得ることができる。

【0056】また、本発明においては、磁化反転が自由にされてなる強磁性層に対して一方向の磁気異方性を誘起させて磁区を安定化する反強磁性体の反強磁性層を設けたので、強磁性層を単磁区化することができ、外部磁界によって強磁性層の磁化反転の方向をピン止めされた強磁性層の磁化の方向と異ならせることにより抵抗変化を生じさせることができ、この抵抗変化により外部磁界を感度良く検出できるとともに、バルクハウゼンノイズを無くすることができる。また、強磁性層を単磁区化することにより、線形応答性の優れた磁界検出ができる。更に、磁化反転がピン止めされた強磁性層の磁化と磁化の反転が自由にされた強磁性層の磁化の向きが90°異なることにより、効率良く大きな磁気抵抗変化を得ることができる。また、磁化の向きをピン止めする反強磁性層として、 α -Fe₂O₃の層を用いるならば、 α -Fe₂O₃のネール温度が高いことに起因して、熱変化に強く、熱変化によって検出感度の低下しない磁気抵抗効果型センサを提供できる。

【0057】次に、縦バイアス印加のための反強磁性層が、磁化反転が自由にされてなる強磁性層の感磁部分の両端側に感磁部分の幅に相当する所定のトラック幅をあけて強磁性層に接して対向配置されてなることで、強磁性層の感磁部分の両側に一方向性の磁気異方性により縦バイアスを印加できるとともに、強磁性層の感磁部分の磁化反転を容易にすることで、縦バイアスを印加して線形応答性の良い、バルクハウゼンノイズの無い状態で抵抗変化を得ることができる。

【0058】次に、磁化反転を自由にされた強磁性層が、トラック幅に相当する感磁部分の幅の分のみ形成され、その強磁性層の両側に形成された反強磁性体の反強磁性層と他の強磁性層との積層体により縦バイアスが印加されてなることで、強磁性層に一方向性の磁気異方性

により縦バイアスを印加できるとともに、強磁性層の磁化反転を容易にすることで、縦バイアスを印加して線形応答性の良い、バルクハウゼンノイズの無い状態で抵抗変化を得ることができる。

【図面の簡単な説明】

【図1】 本発明に係る磁気抵抗効果型センサの第1の形態を示す断面図。

【図2】 図1に示すセンサの各強磁性層の磁化の向きを示す図。

【図3】 本発明に係る磁気抵抗効果型センサの第2の形態を示す断面図。

【図4】 本発明に係る磁気抵抗効果型センサを備えた薄膜磁気ヘッドの斜視図。

【図5】 図4に示す薄膜磁気ヘッドの要部の断面図。

【図6】 図4に示す薄膜磁気ヘッドの一部を断面とした斜視図。

【図7】 実施例試料の抵抗変化曲線を示す図。

【図8】 α -Fe₂O₃を用いた磁気抵抗効果型センサ試料のブロッキング温度を示す図。

【図9】 図9 (A) はピン止め強磁性層の磁化曲線、図9 (B) は磁気抵抗効果型センサの磁気抵抗曲線を示す図。

【図10】 従来の磁気抵抗効果型センサの第1の例を示す断面図。

【図11】 従来の磁気抵抗効果型センサの第2の例を示す断面図。

【図12】 従来の磁気抵抗効果型センサの第3の例を示す断面図。

【図13】 従来の磁気抵抗効果型センサの第4の例を示す断面図。

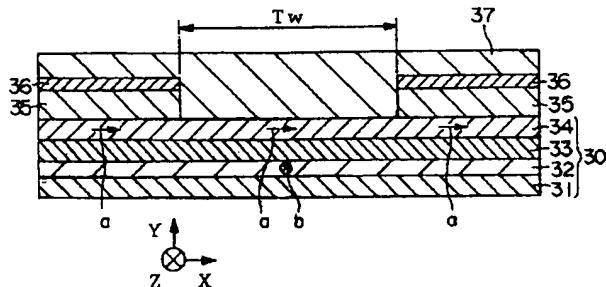
【図14】 従来の磁気抵抗効果型センサの第5の例を示す断面図。

【図15】 従来の磁気抵抗効果型センサの第6の例を示す断面図。

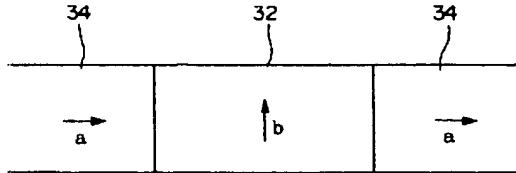
【符号の説明】

3 0	磁気抵抗効果素子
3 1、 4 1	保磁力増大層
3 2	強磁性層
3 3、 4 3	非磁性層
3 4	強磁性層
3 5	反強磁性層
3 6	リード層
4 2	ピン止め強磁性層
4 4	フリー強磁性層
4 6	反強磁性層
4 7	強磁性層
4 8	導電層

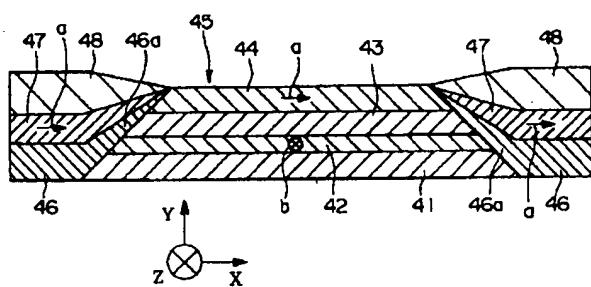
[图 1]



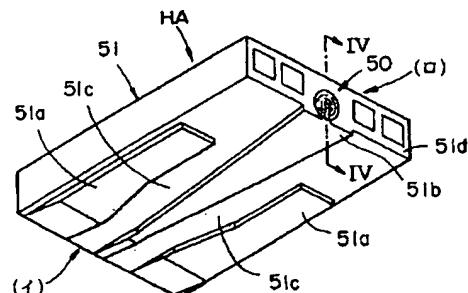
〔図2〕



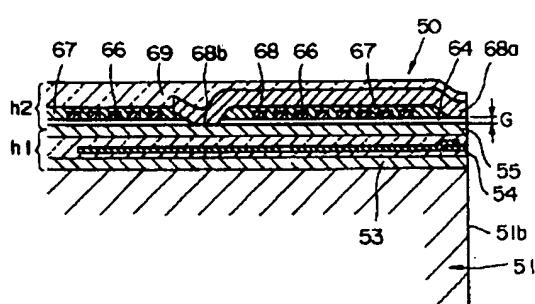
(图3)



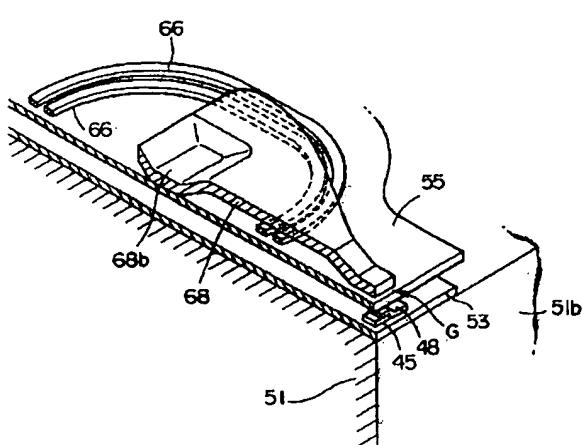
[図4]



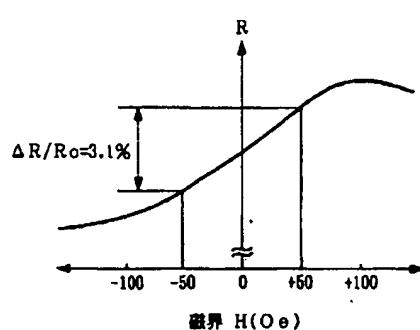
〔四〕 5



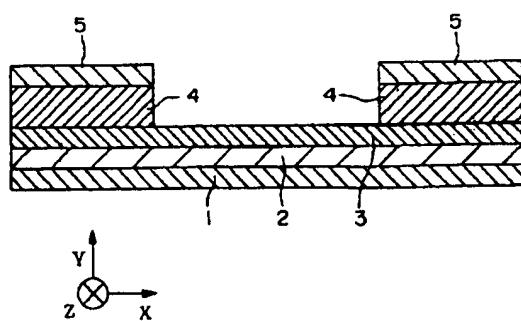
[図6]



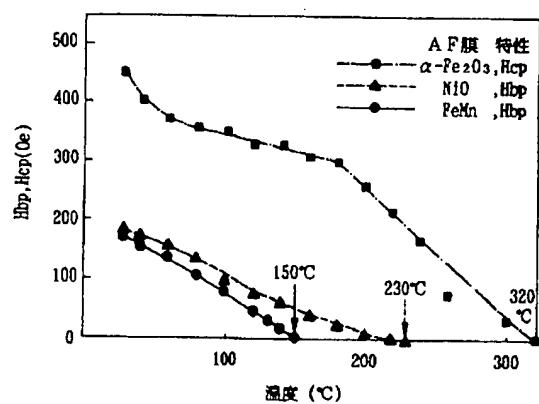
[図7]



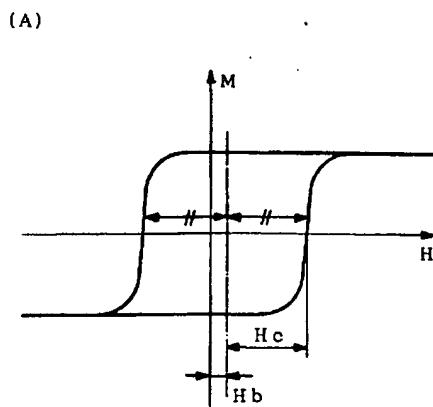
[图 10]



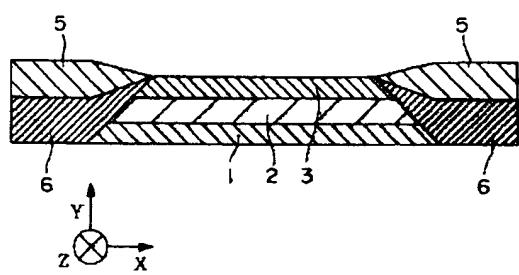
【図 8】



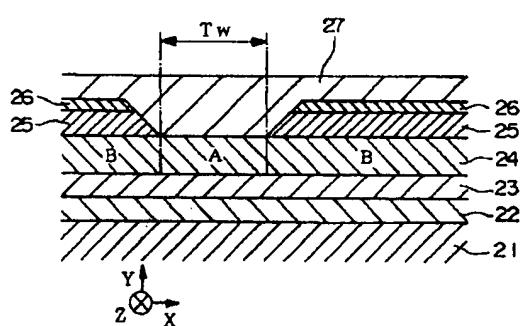
【図 9】



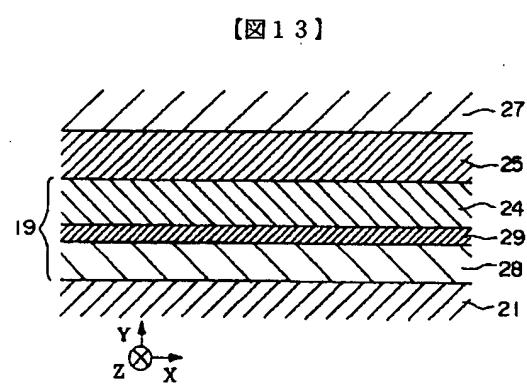
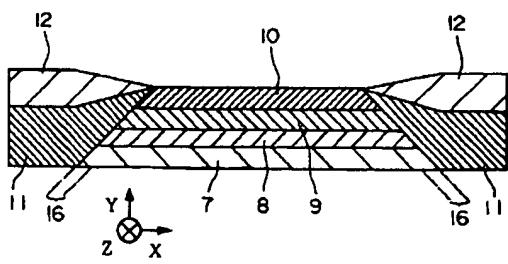
【図 11】



【図 12】



【図 14】



【図 15】

